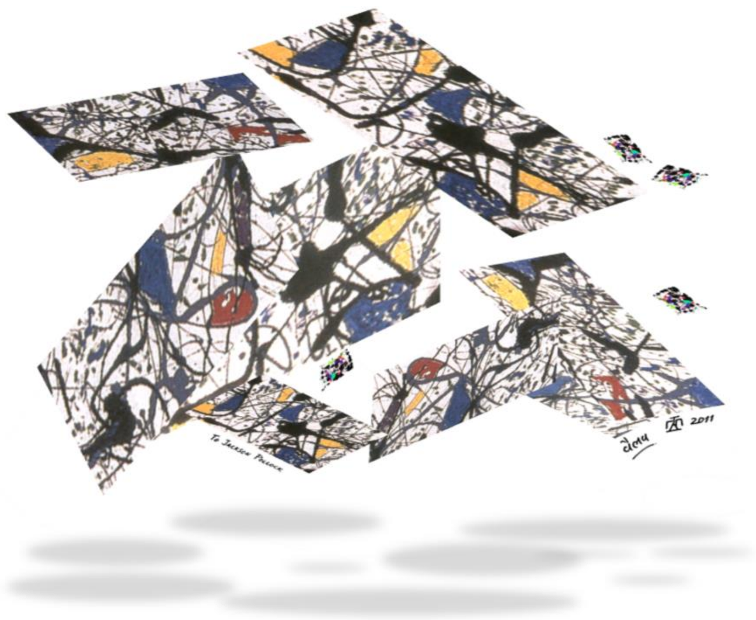
BUSINESS SUSTAINABILITY 2.0

Management, Technology and Learning for Individuals, Organisations and Society in Turbulent Environments

Edited by:

Goran D. Putnik

Paulo Ávila



Chaos and Sustainability – the 2nd Order 2.0

Universidade do Minho

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FOREWORD

This book presents the collection of fifty papers which were presented in the Second International Conference on BUSINESS SUSTAINABILITY 2011 - *Management, Technology and Learning for Individuals, Organisations and Society in Turbulent Environments ,*held in Póvoa de Varzim, Portugal, from 22nd to 24th of June, 2011.The main motive of the meeting was growing awareness of the importance of the sustainability issue. This importance had emerged from the growing uncertainty of the market behaviour that leads to the characterization of the market, i.e. environment, as turbulent. Actually, the characterization of the environment as uncertain and turbulent reflects the fact that the traditional technocratic and/or socio-technical approaches cannot effectively and efficiently lead with the present situation. In other words, the rise of the sustainability issue means the quest for new instruments to deal with uncertainty and/or turbulence.

The sustainability issue has a complex nature and solutions are sought in a wide range of domains and instruments to achieve and manage it. The domains range from environmental sustainability (referring to natural environment) through organisational and business sustainability towards social sustainability. Concerning the instruments for sustainability, they range from traditional engineering and management methodologies towards “soft” instruments such as knowledge, learning, and creativity. The papers in this book address virtually whole sustainability problems space in a greater or lesser extent. However, although the uncertainty and/or turbulence, or in other words the dynamic properties, come from coupling of management, technology, learning, individuals, organisations and society, meaning that everything is at the same time effect and cause, we wanted to put the emphasis on business with the intention to address primarily companies and their businesses.

Due to this reason, the main title of the book is “Business Sustainability 2.0” but with the approach of coupling Management, Technology and Learning for individuals, organisations and society in Turbulent Environments. Also, the notation“2.0” is to promote the publication as a step further from our previous publication – “Business Sustainability I” – as would be for a new version of software.

Concerning the Second International Conference on BUSINESS SUSTAINABILITY, its particularity was that it had served primarily as a learning environment in which the papers published in this book were the ground for further individual and collective growth in understanding and perception of sustainability and capacity for building new instruments for business sustainability. In that respect, the methodology of the conference work was basically dialogical, meaning promoting dialog on the papers, but also including formal paper presentations. In this way, the conference presented a rich space for satisfying different authors’ and participants’ needs. Additionally, promoting the widest and global learning environment and participation, in accordance with the Conference's assumed mission to promote Proactive Generative Collaborative Learning, the Conference Organisation shares/puts open to the community the papers presented in this book, as well as the papers presented on the previous Conference(s). These papers can be accessed from the conference webpage (http://labve.dps.uminho.pt/bs11).

In these terms, this book could also be understood as a complementary instrument to the Conference authors' and participants', but also to the wider readerships' interested in the sustainability issues.

The book brought together 107 authors from 11 countries, namely from Australia, Belgium, Brazil, Canada, France, Germany, Italy, Portugal, Serbia, Switzerland, and United States of America. The authors "ranged" from senior and renowned scientists to young researchers providing a rich and learning environment.

At the end, the editors hope, and would like, that this book to be useful, meeting the expectation of the authors and wider readership and serving for enhancing the individual and collective learning, and to incentive further scientific development and creation of new papers.

Also, the editors would use this opportunity to announce the intention to continue with new editions of the conference and subsequent editions of accompanying books on the subject of BUSINESS SUSTAINABILITY, the third of which is planned for year 2013.

Guimarães, November-2011

Goran D. Putnik

School of Engineering
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ISEP – School of Engineering
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Porto, Portugal

Figure 1. Logo of the Second International Conference on Business Sustainability

Figure 2. People in the centre

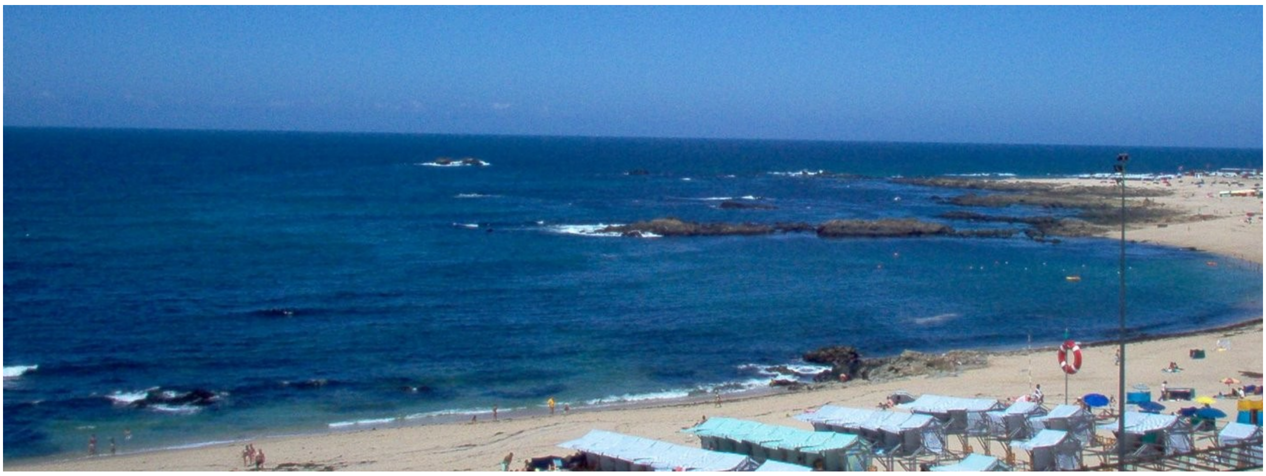

Figure 3. The natural environment

GUIDELINE FOR CITING

Please note, to cite a paper published in this book give reference to the editors {**Putnik G. D., Ávila P. (Eds.)**}, publication title {**Business Sustainability 2.0**}, and publishing place and publishers {**Guimarães: School of Engineering – University of Minho; Porto: ISEP – School of Engineering – Polytechnic of Porto**}; and do not refer to the event/conference where the paper was presented.

An example is given here (the structure and format are subject to changes as per your intended publication's formatting & citation guidelines):

> Eijkman, H. (2011). Socializing for sustainability: towards performative knowledge architectures for neo-millennial organizations. In Putnik G. D., Ávila P. (Eds.), *Business Sustainability 2.0.* Guimarães: School of Engineering – University of Minho; Porto: ISEP – School of Engineering – Polytechnic of Porto. pp. 003-013.

ABOUT THE COVER

Designs on the exterior of this book and the accompanying disc are co-authored by Goran Putnik, and Vaibhav Shah, whose signatures are depicted on the designs. Continuing with the theme from the previous publication, Business Sustainability I, the cover designs are adopted from the same art pieces which were used in the cover of Business Sustainability I publication. The new book's design work is in line with the title (2.0), showing the next phase of the 2^{nd} order of Chaos and Complexity.

These designs are partly inspired from / influenced by the works of the legendary American painter artist Paul Jackson Pollock, famous for his abstract expressionist style. The designs could be interpreted as description / metaphors of chaotic order of events and processes, and sustainability as a major/sought requirement/approach in usually complex and chaotic multifaceted multi-group job – i.e. collaborative business. The authors of the designs have given a tribute to the artist and his work and given a message of Business Sustainability from their interpretation / metaphor of a complex system.

Note about the creation of the cover designs: The building block of the designs is "cropped" from an image of Jackson Pollock's art work titled "Summertime: Number 9A" (1948).

Vaibhav Shah

Goran D. Putnik

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COMMUNICATIONS

INNOVATION AND THE SUSTAINABILITY JOURNEY

Peter Smith, The Leadership Alliance Inc. (Canada), pasmith@tlainc.com

Abstract: This lecture focuses on the sustainability of public and private sector organizations functioning in complex environments locally and/or globally. Sustainability is defined in a "triple bottom line" manner as the capability of organizations to be viable over extended periods of time whilst being exemplars in leading the way in avoiding potential or real negative ecological and social impacts related to their activities.

In particular, this lecture explores how innovation may be targeted strategically to build or enhance sustainability capabilities, and it focuses on both "Learning to Innovate for Sustainability" and "Innovating to Learn about Sustainability". Organizational sustainability is treated as a journey toward self-actualization in sustainability terms, where organizational behaviors leading to more advanced stages of sustainability development may be identified. Stages of innovation-sophistication parallel the sustainability stages, and by exploring and optimizing capabilities such as innovating-to-learn about sustainability, and learning-to-innovate for sustainability, practical progress on the sustainability journey will be made.

Keywords: Sustainability, complex environments, Organizational sustainability.

VIRTUAL AND VIRTUALITY: IMPLICATIONS FOR KNOWLEDGE MANAGEMENT

Jovan Filipovic, University of Belgrade (Serbia), jovanf@fon.bg.ac.rs

Abstract:

The main thesis of the paper is that knowledge cannot be understood without notion of virtuality. In this context the paper presents in the first part the issue of knowledge management and in the second part presents the concept of virtuality form the complexity science perspective. The conclusion is that the knowledge cannot be managed and therefore it is not correct to “talk” about “knowledge management” (KM) but rather about “management for knowledge” (MK). In the third part the concept of Diaspora Virtual University (DVU) is elaborated as a case study for the approach presented. Main ideas on which the thesis and the case study are built are as follows:

Etymologically virtual, originated from the Latin "*vir*" ("man" in an idealized sense), from which arose the Latin "*virtus*" (strength, manliness, virtue), means full of virtue. Virtue is understood as the capacity to act. So, virtual is a “capacity to act”, “the knot of tendencies or forces that accompanies” an entity, which “invokes a process of resolution: actualization” and implies the production of new qualities, a transformation of ideas, a “set of powers to act that reside in the multitude”. The “real” nature of virtuality reminding that “the virtual has existed as long as beings have had imagination; it is the meaning behind the text of a book, the picture beyond the edges of a painting and the story behind a sculpture.” Cultural and technological developments are those that shape our perception of virtuality and the ways we communicate it to others. The lack of solid theoretical framework and narrow concentration on computer technology encouraged the development of a skewed interpretative framework for virtual and virtuality.

Although the totality of our knowledge is always a combination of virtual and actual knowledge, the knowledge management literature insists almost exclusively on actual, while neglecting virtual knowledge. Knowledge is viewed as a stock, a tangible resource, another form of information, there is no dilemma; knowledge management is not an oxymoron. Since knowledge is characterized by emergence we cannot talk about knowledge management, because knowledge cannot be managed. So, “Knowledge management is then the task of creating an appropriate environment — an environment, which allows such willingness [to act] to occur”. Therefore, rather than talking about knowledge management, we can talk about management or managing for knowledge, which is a collective phrase for a set of processes and practices used by e.g. DVU type organizations to enable creation of environment conducive of knowledge emergence and spreading. Combining different metaphors, this study arrives at an amalgamation which clarifies the meaning of virtual and contributes to a better comprehension of DVU.

Keywords: Virtual, Virtuality, Knowledge Management, Diaspora Virtual University.

SOCIALIZING FOR SUSTAINABILITY: TOWARDS PERFORMATIVE KNOWLEDGE ARCHITECTURES FOR NEO-MILLENNIAL ORGANIZATIONS

Dr. Henk Eijkman, University of New South Wales, ADFA Campus, Canberra, Australia, h.eijkman@adfa.edu.au

Abstract: This paper addresses a significant theoretical gap in the organizational learning and social media literatures by analyzing the implications of the social turn in learning and social media for organizational learning and knowledge management. The social turn signifies a distinct rupture with individualistic learning, universally valid knowledge, and an information-centric Web. Taken together they point to the emergence of new paradigm performative knowledge architectures. This macroshift takes us into new territory in terms of epistemology; our understanding of the nature of knowledge; how we acquire, create, share, and capture it. At minimum there are issues around epistemic compatibility; the need for a reasonable degree of commonality in assumptions about knowledge that are embedded in an organization's knowledge architecture, in its use of social media; and the assumptions held by organizational participants. Two premises underpin this paper. First, that this socially focused and performance oriented approach to knowledge will inevitably disrupt if not subvert traditional power-knowledge systems. Second that the successful appropriation of the social turn in learning, knowledge, and the web demands that the organization's epistemic architecture needs to focus on acculturation and participatory practices. The paper concludes by sketching out three enabling strategies around epistemic coherence, scale of participation and a focus on acculturation.

Keywords Social media, Information media, Epistemology, Acculturation, Organizational knowledge work, Power-knowledge system, Discourse communities, Performative knowledge architecture.

INTRODUCTION TO A SOCIAL MACROSHIFT IN ORGANIZATIONAL KNOWLEDGE ARCHITECTURES

The popularity of the various forms of constructivism evident in education for at least a decade or two is an indicator of the growing appreciation of the limitations posed by psychologist approaches to learning and, concomitantly, the new opportunities offered by a more social understanding of knowledge. This includes a more recent, and paradigmatic, shift from theories of *social learning* to *social theories* of knowledge. Whereas the former stresses learning as a collaborative venture of which the end point is still cognitive processing, the latter argues that learning, no matter how or where it takes place, is primarily about acculturation in which knowledge enables one to become a competent member of a specific discourse community [1][2]. Additionally, the social turn in the knowledge domain is now accompanied, and arguably strengthened by a distinctive social turn in Information and Communication Technologies (ICT). The information-centric Web 1.0 has given way to a rich suite of social media spaces, henceforth referred to as information media and social media respectively. Whereas the information media is primarily the world of one-to-many, read-only, static web pages, and learning content, social media introduces radical changes in the production, distribution, evaluation, and use of knowledge to the point that the kind of knowing involved in socialized organizational learning is "very different … much of the knowing that is involved in the new spaces might better be understood in terms of a performance epistemology – knowing as an ability to perform" [3, p.183]. The purpose of this paper is to deal with some of the deeper issues that underpin the socialization of knowledge and the Web and thereby assist in generating new 'knowledge governance' arrangements.

The core argument this paper is that when combined, these now co-evolutionary developments in socializing knowledge and the Web *can* play a key role in socializing organizational knowledge cultures geared much more specifically towards procedural knowledge and performance. However, the shift in underpinning assumptions about learning and knowledge are of such magnitude that simply adding social media to conventional knowledge practices sets up incompatible currents. The sociality in social media will work against the grain of traditional, individualistic learning and propositional knowledge practices. The epistemic tensions embodied in the socialisation of learning and the Web are substantial and significant. Social media engages all participants in very different modes of knowing that demand more mature, open and transparent, forms of authentic, real world, “non-scholastic social practices” [3, p.177]. As such these participatory spaces pose a fundamental challenge to conventional learning practices and their underpinning assumptions, and to a system in which the authority of knowledge is centralised and vested in organizational or professional elites.

Ultimately, the appropriation of social media for organizational learning involves, as [4] points out “an apprenticeship in new kinds of knowledge practice”. The critical issue is that in terms of learning, social media embodies or is at least much more open to, understandings of knowledge based on human sociability. Social media’s epistemic framework stands in opposition to the dominant and conventional organizational learning practices that privilege propositional knowledge and individualist and information-centric practices.

Pursuing this argument further, the paper suggests that the effective appropriation of social media based learning and knowledge practices at minimum demands a reasonable degree of coherence, firstly around the assumptions participants and stakeholders have about the nature of knowledge and learning as well as coherence in actual organizational knowledge practices. The effective appropriation of social media therefore demands that we begin to have conversations about the nature of knowledge and how it is acquired and shared. This conversation proposes that we situate social media within a ‘performative knowledge architecture’; an overarching framework focused on learning as acculturation, knowledge as communally constructed, and the new Web as a rich, multifaceted participatory knowledge space. From this perspective, such an architecture of acculturation, social construction and participation is sustained by a performance oriented *socio-cultural* episteme that foregrounds procedural knowledge and performativity.

Borrowing from [5] we may well consider these unprecedented changes a ‘macroshift’; a fundamental transformation of organizational knowledge work in which technology provokes a critical mass of people to, in a sense, either ‘go down’ with increasingly defunct old paradigm practices or boldly create something radically new. As pointed out by [6] “social media represents the first time that technology is encouraging a deepening of connections between people - a key reversal in the trend that technology has been playing since the industrialization wave that has shaped our society”. Organizations are invited to adopt very different ways in which to create, evaluate, and capture knowledge by considering more socio-performative approaches to knowledge practices.

Hence the paper, drawing on insights from the fields of the sociology and philosophy of knowledge, aims to reveal how the combination of socialized knowledge work and social media heralds a transformation in organizational knowledge architectures [7]. It makes explicit the usually implicit assumptions about the nature of knowledge and how it is constructed in both conventional and socio-performative approaches to organizational knowledge work. The paper begins by analyzing the latest iterations in the social turn in learning and the Web and why both constitute a paradigmatic break with the past. An analysis of their performative learning potential follows. The paper concludes with a set of questions to guide to the implementation of performative learning strategies around three key themes; epistemic coherence, scale of participation, and focus on acculturation.

Throughout I use the terms information and social media to refer to Web 1.0 and Web 2.0, and its later iterations, respectively. The term ‘discourse communities’ refer to groupings of people who, having a common focus, institutionalise a particular communicative structure (cultural practices), conventions, discourses, power arrangements, institutional hierarchies, and vested interests [8] [1].

The social turn in learning: towards performative knowledge architectures

Whereas the social turn in digital technologies has been a very public affair – at least at the operational if not the epistemological level – the latest social turn in the socialization of knowledge has been a much quieter event. Quiet maybe, but important nevertheless because, as I will argue, organisations will never fully utilize the affordances provided by social media as long as their conceptual framework remains wedded to an old paradigm, individualist, cognitive mental model of learning and knowledge. A socialized architecture of learning and knowledge is therefore a necessary pre-requisite for effectively leveraging the affordances of social media.

For our purposes, and in admittedly broad brushstrokes, we conceptualize the socialization of learning and knowledge as consisting of at least two distinct waves. Following the shift from the behavioural to the cognitive, the first wave of socialization consist of new *theories of social learning* as represented by the broad church of constructivisms epitomized by figures such as [9],

[10] etc. Suffice to say that, as reflected in its vast literature, the unifying premise of constructivism, which includes activity theory and social constructivism, is the emphasis on learning as a social activity. Learning is seen to be much more efficacious when it occurs within a collaborative context. However, and this is a key point, the social is a means to a cognitive end; learning socially is simply a better way of getting knowledge into the heads of individuals [11]. As [12, p.51] points out, constructivism offers “a *psychological* description of knowledge [that still] deals with knowledge formation *in the head*” (original emphasis). For our purposes this means that in terms of the social turn, constructivism, as a theory of social learning is only a partial response (see Figure 1). It largely accepts the realist/essentialist view that knowledge is gained from observations of the real world and is therefore objective and universally ‘true’ and is acquired via cognitive processes within individuals. The point here is that the social paradigm embodied in *social theories of knowledge*, and which find greater voice in social media, strongly contests this conceptualization of knowledge, which in constructivism still remains largely uncontested.

Psychologist theories	**Social learning theories**	**Social theories of knowledge**
Behaviouralism	Constructivism	Social Constructionism
Cognitivism High	Social Constructivism	
Developmental theory		

Fig. 1. The social turn in learning continuum

In contrast, the second wave, that of *social theories* of knowledge, signals a distinct break with psychologist theories of learning and realist/essentialist knowledge claims. In social theories of knowledge [2] [3], the focus broadens to also address concerns around the product of learning, namely knowledge. Here the knowing subject is not the individual but the discourse community to which individuals belong. Knowledge, now understood as emerging out of human sociality and therefore as situated within specific discourse communities, is seen to have an inherently social purpose. Its sociality lies not necessarily in people learning together but in the acquisition of social competence. Learning, rather than being an individual cognitive process is about being acculturated into a discourse community. The primary aim of learning is to acquire procedural knowledge; knowledge that enables one to become and perform as a competent member of that community. Here, the reference point for knowledge is neither internal (the individual mind) nor external (the empirical world) but social, namely the sociality situated within specific discourse communities [2] [13] [1]. In other words, the discourse communities to which we belong always mediate everything we perceive and come to know so that “the ‘reality’ that we impute to the ‘worlds’ we inhabit is a [socially] constructed one” [10, p.169]. As such knowledge is what a discourse community ‘institutionalizes’ in its culture, its archive [14, p.5], and in its prevalent power-knowledge system. This makes knowledge a *socio-cultural* artefact, a product of historically situated interchanges among members of particular group of people at a particular point in time. From this vantage point learning is understood as something that occurs “primarily *outside* the head, between participants in social relationship” [12, p.51]. It follows from this that our knowledge of the world is always partial and situated with no one interpretation being superior to another. Knowledge and truth are epistemically (but not morally) relative and therefore not necessarily universally valid or true. From this perspective learning is about critical acculturation of newcomers into a discourse community. It’s about entering, negotiating membership of, and becoming a proficient insider into that community and learning to negotiate the meanings of its discourse and become proficient in its practices and knowledge systems, and about transforming our identity from novices to proficient insiders.

If social competence or performance is always the beginning and endpoint of all learning, then gaining knowledge is always a social project even if we do so individually. For example Robinson Crusoe, though alone, saw, interpreted, and acted upon ‘his’ island not as a culturally abstracted individual but as a member of his (albeit geographically distant) discourse community [13]. This is what sets the social *theories of knowledge* apart from *theories of social learning* [2]. Succinctly put, the social turn *as embodied in social theories of knowledge* represent a paradigm shift “with specific and multiple impacts on the nature of knowledge, and therefore on the nature of learning” [4, p.1]. For example, the shift in epistemic emphasis from the individual to the collective is that it changes the constitution of ‘knowers’ and what it means ‘to know’ [3].

At this juncture one may ask why belabour this point, why is this so important? Two important implications are attached to this paradigm shift. First, it implies that knowledge claims need to be negotiated, as is the case where people from discourse communities around the globe are able to posit competing knowledge claims something social media now effectively enables. Social theories of knowledge also bring issues of power into play. Once we accept the need to negotiate among competing discourses to decide for instance on the situational utility one discourse may have over another, we begin to recognize that the capacity to negotiate depends greatly on where people are situated in current power-knowledge systems. The heated debates about Wikipedia amongst educators especially, are indicative of the significance and contested nature of this shift in knowledge and knowledge construction that underpins the effectiveness and hence popularity of social media [15]. The point is that social theories of knowledge are explicitly and inherently open to multiple knowledge claims, especially when they emerge out of very different discourse communities. Those holding these positions are therefore naturally comfortable with a world in which the authority of knowledge is distributed and in which knowledge claims are always subject to negotiation [16][17][18][19][13][1][20]. I venture to argue that this is clearly an advantageous position when engaging in social media.

Second, and as prefigured by Lyotard as early as 1984, the post-industrial intensification and entrenchment of new technologies helps to shift the emphasis from propositional to procedural or performance focused knowledge. The principle of performativity, "the endless optimization" of performance [21][22] signals a fundamental change in the status of knowledge, something already evident in social theories of knowledge and is, by extension, is a potential of social media in organizational settings.

The relevance of a social theory of knowledge becomes more pertinent when considering the appropriation of social media into organizational settings, and not merely as yet another suite of Web-based technologies but as a new, in fact a very new way of thinking about knowledge management; the creation, sharing, and evaluation of knowledge.

Social media as a macroshift in thinking about knowledge and learning

Social media is a rather wide-ranging concept, or better put, a new vision of how producers and users can interact with each other on the Web. Essentially, social media is about the exponential increase in modes of communication, participation and social interaction that the Web now enables. The term 'Web 2.0' refers to a broad suite of social networking and mass authoring tools that make it increasingly easy for users to combine or render content in new and novel forms ('mashups') and do so increasingly in open-access content and open source software [23][24][25]. On the other hand the use of the term 'social media' places the emphasis elsewhere, on social networking and on relationship building; activities whose results primarily depend not on technologies but on their users. The Web while necessary is not sufficient! Importantly, all social media services and applications have two crucial features in common. First, all services and applications are built on a platform of participation in which the boundary between producers and users has been all but obliterated [26][27]. Second, and building on the first, but at a deeper level, they embody or promote the social turn in epistemology; the socialization of knowledge.

Social media services and applications are, to a larger or lesser degree, underpinned by or at least much more open to, a distinctly social understanding of knowledge. Social media is supportive of a public or communally-centred participatory paradigm that distributes rather than centralises epistemic power *and* authority. These two features can transform organizational knowledge architectures away from being information-centric to being communication and relationship centred. In a performative knowledge architecture, to borrow from [28, p.4] "collaboration, contribution and community are the order of the day" to a point where "a new 'social fabric' is being constructed before our eyes". In one way or another social media's rich participation-driven suite of social networking and mass authoring tools is redefining the way we use the Web for knowledge construction [3][29][30][31][32][33][34]. Social media's more mature architecture of participation and its social-performative epistemology irrevocably changes the way people now engage with each other in the quest for knowledge.

By foregrounding people, conversation and connectivity rather than information "social media is about a scaling up of participation that creates new possibilities for sharing and network effects" [33, p.8]. There is here a real focus on *users as generators as well as consumers of multimedia forms of communication;* on repositioning users as 'first class entities' [35][36].

In concert with the social turn in learning, social media's epistemic framework also foregrounds performance. In organizational learning there is a distinct privileging of procedural knowledge; a preference for 'knowing how' rather than on 'knowing what'. The emerging epistemic picture of social media reveals it is implicitly more comfortable with a distinctly sociological view of knowledge, where knowledge is understood as something always mediated by and situated in discourse communities (see for instance [1][12]. At any rate, because the curators of 'digital assets' are increasingly communal rather than institutional, user ownership and control over knowledge production is greatly strengthened. Users can now generate content with *decreasing* reference to geographic, cultural, institutional, and disciplinary boundaries and constraints [37].

The participatory architecture of social media provides much more sociable and egalitarian spaces that are much less amenable to domination by technophiles and professional elites. This acts to undermine or disrupt our conventional power/knowledge systems. The conceptual architecture that underpins social media has irrevocably shifted the emphasis away from the information media's primary role as a hierarchic, top-down, information repository and its associated 'information fetishism' [38]. The point is that social media challenges conventional assumptions about what constitutes knowledge and knowing in the digital age. The emphasis shifts from the individual to the collective, which in turn changes how 'knowers' are constituted in relationship to other 'knowers' as well as "the relative significance of, and balance among, different modes of knowing" [3].

Social media invites a deep seated cultural shift in our approach to knowledge work. Participants are now positioned differently vis-à-vis a vastly expanded, less hierarchically situated, and more culturally diverse, range of 'others'. This means that knowledge construction is far less constrained by cultural, institutional, or disciplinary boundaries and, because of its grassroots, bottom-up approach, is much more open to alternative viewpoints and perspectives that challenge or even subvert our 'industrial model' power-knowledge systems; its rules, procedures, and limits [39][40]. It defies many of its accepted rules and regularities, overthrows some of its limits and exclusions, opens up the 'conditions of possibility' by extending the range of what is possible and legitimate to 'know', and how one can 'know'. It questions accepted norms about what counts as reason, argument, and evidence (note the simultaneous rise in concern about plagiarism in higher education), and what constitutes valid and valuable knowledge [41]. The once solid boundaries around the ownership of epistemic authority have, to borrow from Marx, 'melted into air'.

While not underestimating the continued need for a critical appraisal of these changes such as advocated by [42] and many others, when taken together the essentially distinctive features of all of social media's applications and services is their emphasis on sociability, on more open, egalitarian and transparent participation in the communal production, sharing, and ownership of knowledge. Arguably this epistemic shift is of such magnitude that it will generate internal tensions in our current power/knowledge systems to a point where the stresses will precipitate either its stagnation or the breakthrough of new, more participatory knowledge architectures [34][31]. As Laszlo stresses, "Macroshifts are triggered by technological innovations that destabilize the established structures and institutions of society. More adapted structures and institutions await the surfacing of a more adapted mindset in the bulk of the population" [5].

Thus, while this new knowledge construction phenomenon is driven by technology, is not reducible to it. The really important transformation is a human and not a merely technological one. It is the former rather than the latter that drives the pressure for change. What we are dealing with here is a fundamental transformation. The question is how organizations will respond to this new paradigm, at the operational *and* epistemic level.

Facing the future: social media and performative organizational learning

The performative episteme embedded in social media represents both new challenges as well as a window of opportunity to address long standing issues in knowledge management within and across organizations [43][44][45][46][42][47]. The central question deploying social media in organizational settings is how to critically appropriate its social-performative agenda. I propose two strategies.

Firstly, it is useful to replace an emphasis on the technological with a systemic focus on the socialization of knowledge and knowledge construction. This makes it clear that social media invites us to engage with knowledge in new ways and that this invitation has an 'RSVP' attached to it. In other words we are asked for a response to this reframing of knowledge; of who we are as knowers; of the processes of coming to know; and of what knowledge and ways of knowing are actually valued [48].

A second appropriation strategy is to consider any potential use of social media along three fundamental design criteria; the degree of epistemic coherence, the scale of participation and, the extent to which learning focuses on acculturation. As a guide we can ask, in relation to our own organizational context, 'what degree of epistemic coherence, participation and acculturation would be most appropriate?' As shown in Figure 2 each criterion offers a continuum of choices rather than a forced dichotomous either/or position. This enables organizations to identify their desired position on each criterion, consider the impact of trade-off's and anticipate potential challenges.

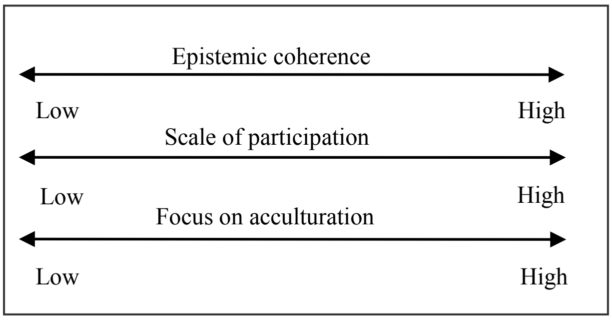

Fig. 2. A continuum of choices

The degree of epistemic coherence

The epistemic stance of social media is such that "the creation, circulation, valuation, and use of knowledge have changed" [49, p.2]. This calls for a critical re-evaluation of the advantages and disadvantages of both old and new knowledge practices, and a reframing of assumptions about learning and knowledge practices. While there appears to be a great deal of incommensurability between conventional organizational knowledge work and the performative knowledge orientation embodied in the social turn, there may also be valuable pedagogic and curricular trade-off's and the possibility of hybrid approaches. Evaluating epistemic alignment calls for a cost-benefit analysis. For example, what are the potential benefits of epistemic alignment between organizational knowledge practices and the social-performative focus inherent in social media? What are the possible costs of lower levels of alignment or even misalignment, and how do we resolve this issue of alignment to optimise knowledge work?

The point here is that social media as [49] points out, is not just about offering personnel new technologies to use but *to offer them an apprenticeship in new kinds of knowledge practice*. It is important therefore that we make this 'apprenticeship' explicit. The question about alignment, broadly put, is about how participants in organizational learning can engage productively in such an epistemic apprenticeship?

Questions about epistemic coherence might include the following.

- To what extent is the required knowledge work a high stakes-high risk project, and how should this influence the level of engagement with social media, especially if participants are not familiar with its new implications for knowledge?
- How conventional is the epistemic worldview of the organization and its personnel? What scaffolding is needed to promote a smooth transition not just to social media but to a socialized knowledge culture?
- How important, in specific contexts, is propositional knowledge compared to procedural-performance knowledge? How can specific social media applications and/or services best support the acquisition of such knowledges?
- If there is an epistemic mismatch between social media and an organizational knowledge culture and expectations, what are the potential effects and how can they be dealt with?
- Is an explicit awareness of any epistemic differences helpful in itself? For example, does it help for participants to have an explicit understanding about how they are framed vis-a-vis each other and to the knowledge construction process? Will an explicit acknowledgement of degrees of alignment or misalignment make it possible to proactively incorporate useful allowances or ameliorative strategies?

From this perspective both information and social media have to be reviewed for their relevance, strengths, and limitations [50][51]. If the rather hasty dismissal of Wikipedia by many is any indication, those wedded to a conventional epistemology may find such an epistemic review, let alone possible reframing, quite challenging in itself [15].

In the final analysis it is not the digital technology but the epistemic worldview of participants that will determine how they and other 'knowers' are framed and conceptualised, and how effectively social media will be deployed.

The scale of participation

Central to social media is the shift from control to participation and consequently the problematic "passionate drive to keep the Internet as free of authority and control as possible" [3, p.175]. While the democratization of knowledge is at the core of social media, issues around control are central to organizational knowledge work. Thus an organizational culture around control and authority over knowledge may well be in tension with, if not opposed to, social media's democratization of knowledge. These tensions pose a most profound challenge to organizational authority over knowledge and will therefore be the focal point for contestation and, hopefully, a great deal of critical analysis and research.

At any rate, social media's preference for the optimization of participation and subsequent role as a disruptive approach to conventional knowledge work is clearly visible in its focus on open access, people-centeredness, the dissolution of boundaries between consumption and production of content, a focus on use rather than exchange value of knowledge, distributed ownership and the removal of layers of control. An organization's need for control may pose a major barrier to the uptake of social media platforms that are open to the world. As suggested by [52, p.48] "the main threat of using SNSs [Social Network Sites] in an organizational learning context arises from a perceived lack of control over the organizational learning space, because of the public nature of such sites, contrasting sharply with more traditional closed environments such as learning management systems". This critical stance is not without foundation given that many commentators see social media as akin to the 'cult of the amateur' [42].

In other words the key issue here is about matching participants' daily experience of the participatory ethos of social media with organizational expectations of the in-house use of social media for organizational purposes [53][54]. Organizations are invited to consider how social media positions participants differently and how to leverage these differences in support of organisational knowledge work. The issue about the scale of participation is about the extent to which organizations enable staff to be co-producers rather than just consumers of knowledge and, conversely, the readiness of staff to engage more actively in this process. Hence, to what degree will organizations promote a participatory mindset or wish to remain sole masters within walled-in cloistered 'knowledge courtyards'?

It seems inevitable that social media's architecture of participation will lead to knowledge work that is less contained or restrained by institutional boundaries such as those currently provided by closed institutional intranets and learning management systems. At this point organizations may be wary of the pressure for greater learner or staff participation and autonomy, interpreting this rather negatively as a serious slippage in their capacity to control and manage the organizational learning experience [55] [33][56][52]. Such resistance may well result in a disruptive organizational digital disconnect and legitimacy crisis [57][58]. Organizational participants familiar with social media's participatory ethos are likely to increasingly question any authoritarian appropriation of democratic social media practices, and if not now, certainly more so in the future. This scenario is especially likely if their organizational learning use of social media bears little or no resemblance to their everyday experiences in which they are positioned as co-producers and co-owners of knowledge.

In considering the scale of participation for optimum learning we may ask:

- What degree of participation would best suit organizational knowledge work and would motivate staff to contribute most effectively? What are the advantages of doing so? How can the voices of staff be heard in the planning process?
- What are the personal and/or organizational opportunities for, as well as constraints on, enhanced participation? How can participation be best negotiated?
- What support structures are useful for promoting participation and changing roles as co-producers of knowledge?
- To what extent can participation in the organizational learning experience match the inherent participatory expectations of social media? To what extent can organizational knowledge work productively tap into the open Web rather than confining participants within the closed walls of a Learning Management System?

Learning as acculturation

Social media (for those who have access) enables access to discourse communities on an unprecedented global scale. The epistemic default position of social media is to reframe participants as actively contributing cosmopolitan members of global networks of practice [2][1]. From this viewpoint, the focus of learning is not on content per se but on acculturation. Learning is about finding the best ways of enabling newcomers to become fully familiar with the culture, discourse, knowledge, worldviews, dispositions, and practices of the discourse communities they are joining or are part of. Learning is about placing people on the most productive trajectories of participation to enable them to progress from 'novices' to fully competent 'insiders' of their respective discourse communities [2][1][56]. Hence all our learning, whether formal or informal, individually or collectively, from childhood on, is always about acculturation into the knowledge system and practices of our discourse community [19]. Accordingly in social media,

> The model of e-learning as being a type of content, produced by publishers, organized and structured into courses, and consumed by students, *is turned on its head*.

Insofar as there is content, it is used rather than read— and is, in any case, more likely to be produced by students than courseware authors. And insofar as there is structure, it is more likely to resemble a language or a conversation rather than a book or a manual" ([29], emphasis added).

In contrast to conventional learning and its emphasis on propositional knowledge, learning as acculturation privileges a performative epistemology as promoted by social media. Therefore acculturation is most effective when we enable learners to embark on trajectories of legitimate peripheral participation in practice-focused, experiential knowledges. This is because these concentrate on direct and authentic experiences of the world rather than institutionally-mediated abstract descriptions of it [2][1].

Hence both learning as acculturation and social media facilitate trajectories of participation in which learning shifts away from *'learning about'* to *'learning to be'* productive members of their discourse communities [2]. This immediately invites substantive changes in knowledge work [3]. The point here is to consider where organizational decision-makers will position organizational knowledge work on this continuum and how that position will frame knowledge work as being content or acculturation oriented. Hence questions we may profitably ask include:

- To what extent do specific knowledge practices favour propositional knowledge (content) or procedural knowledge (acculturation)?
- How do these conventional preferences align with the acculturative-performative emphasis of social media?
- What are the perceived advantages of shifting towards a more acculturative stance in organizational knowledge work? What challenges does it pose for the organization, its instructional staff and learners/participants?

The point here is to consider how participants can get a real sense of their acculturation by being able to capture and track their achievements as they progress on their trajectory of participation throughout their knowledge work. The aim here is to also provide them with practices that enable them to connect more consistently to the culture, language, concepts, expectations, and practices of their real world discourse communities and in ways that enable them – and the organization – to ascertain and celebrate progress.

Not a conclusion but a beginning: towards a systemic postmodern worldview

It is clear that social media provides organizations with very different spaces for knowledge work. Social media's capacity to engender multiple ways of seeing and knowing also undermines the power of traditional gatekeepers to knowledge. Traditional knowledge processes and authority structures, the power to decide what constitutes trustworthy knowledge, are denaturalised as epistemic processes and authority arrangements are opened up and being made much more transparent and open. Understanding knowledge as a distinctly social phenomenon and doing knowledge work in social media has very different consequences for the design of new performative knowledge architectures.

This macroshift calls for a critically reflective approach to this new paradigm and its very different take on the nature of knowledge and the processes of 'how we come to know'. This new socially inclusive reconfiguration of the world of organizational power/knowledge systems requires careful monitoring. Its roll-out into the organizational learning mainstream invites us to negotiate among competing worldviews, values, and practices.

Moving toward a future in which we will more fully integrate social media into the world of organizational knowledge practices will be a challenging process of resolving major tensions and deep-seated dilemmas. As Chowcat et al. point out; much of it will be about identifying drivers, inhibitors and disruptors,

> we will refine our understanding of the trends and, especially, the emerging disruptions through dialogue with the expert community and by engaging in other activities. Activities will include 'sandpit' events (where small groups can engage in-depth with specific technologies to evaluate their organizational learning potential), commissioning a small number of action research projects, and identifying exemplar projects to form the basis of case studies [59, p.6].

For example, participation can, in different circumstances and in different ways be as much a driver as a disruptor as well as an inhibitor of good practice. Action research projects can be useful here in providing a way forward in providing for evidence-based practice. Take the tensions inherent in the popularly conceived 'participation-control 'dichotomy. Embedded in these different directions regarding the centralised or democratic authority of knowledge are highly important considerations. It is critical these be fully and critically explored in ways that take us beyond mindless conservatism on one side or unquestioning digitopian enthusiasm on the other, and beyond dichotomous thinking that places them in an unproductive either/or position to each other. In addition, given the variable exposure to the relatively new social media applications and services by both learners and educators these spaces provide opportunities for a collaborative and strategic approach to implementation. Planning and design for example will benefit at the immediate organizational learning level from wide consultation with stakeholders. It is also clear that given the systemic nature of the change inherent in social media, organizations may benefit greatly by a systemic rather than ad hoc approach to the implementation of social media. Organizations could, for example commission a social media strategic action plan that can begin by identifying low stakes, low risk projects.

In conclusion, and drawing on [4, p.5] I propose that from a minimalist perspective we at least consider the following questions in considering our expanded use of the social turn in learning and the Web:

- What are the critical choices organizations need to make with respect to mental models about knowledge work when considering the appropriation of social media?
- What practices, habits and patterns of use emerge from these epistemic choices? What impact do different patterns of use have on designing performative knowledge architectures and organisational knowledge work?
- What are the critical moments in the changing relationships that participants experience when engaging in social media based knowledge work ?
- How can we define effective learning in epistemically different social media spaces? What skills, strategies, aptitudes and approaches are most effective and useful in such spaces?
- What changes need to occur in institutional policies and practices in order to integrate social media effectively into the mainstream of organizational knowledge work?

All in all, we find ourselves in an exploratory phase of working with social media. This, to use Boorstin's metaphor [60], gives us a 'fertile verge'; a broad liminal 'betwixt and between' space within which we can act and research – and do so simultaneously, as action researchers – if we want to [59]. We will find ourselves increasingly in an organizational frontier region where two different epistemic paradigms will increasingly meet and mingle, and in which we can acculturate ourselves and our organizations into new groundbreaking epistemic practices.

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A SEMIOTIC FRAMEWORK PERSPECTIVE ON COMPLEXITY AND SUSTAINABILITY MANAGEMENT IN ORGANIZATIONS

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Abstract: Management of complexity and sustainability is seen as one of the key issues in nowadays organizations. As this is an emergent discipline there is a question on instruments that management might use in achieving its objectives concerning the complexity and sustainability. However, the nature, as well as the types, of instruments depends largely of the complexity and sustainability definitions and models assumed in the organization. In this paper, the issue of complexity and sustainability management is considered form the semiotics perspective. Semiotics, in its most simple definition, is the science of 'signs'. The signs could be linguistic or non-linguistic, or in other words, verbal and non-verbal. Semiotics comprises three fields: syntax, semantics and pragmatics. While syntax and semantics are well known and largely used in e.g. information systems (for management support), pragmatics is almost totally unknown as a discipline. However, these three semiotic fields are distinguished by the degree of abstraction of the components within the semiosis, i.e. within the "process of creation of signs". While syntax and semantics abstract the concrete users of a language, or signs, pragmatics addresses the concrete user, which could be interpreted as that the pragmatics is an inevitable aspect of the organizational processes if aiming the concrete situation and user. Considering that the guiding principles of the complexity and sustainability management are towards increasing coherence between the organization and the environment, especially under the conditions of dynamic environment, pragmatics, i.e. semiotics, is seen as an emergent discipline in the context of complexity and sustainability management in organizations.

In this paper it is consider the instrumental use of semiotics for the purpose of management, meaning that there might be used models, mechanisms, procedures and processes of semiotics as an independent science as new, or for enhancing of existing, management mechanisms, tools and processes, especially concerning the complexity and sustainability management. In this context, the semiotics framework, which is recently conceived for the purpose of (manufacturing) systems integration, is considered as the framework for complexity and sustainability management in organizations. The semiotic framework is intended to serve "as the criteria or a reference", for 1) guiding the development of the semiotics-based instruments for management of complexity and sustainability in organizations, and 2) for evaluating a concrete management of complexity and sustainability solution's "compliance with the semiotics-based" management paradigm.

The paper's structure has two main parts. In the first part of the paper there are presented the concepts of semiotics, complexity and sustainability. The second part presents an analysis of how the semiotics framework for systems/enterprise integration, used as the framework for complexity and sustainability management, addresses the issues of complexity and sustainability in an organization.

Keywords: Complexity, Sustainability, Semiotics, Pragmatics, Management

ETHICS, GOVERNANCE AND ECONOMIC DEVELOPMENT

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Abstract: In this article we seek to substantiate the relation between ethics, governance of the states and their economic development. Statistical evidences of the relationship between ethics, the levels of governance of the states and their economic performance indicators were found. These evidences suggested that institutions and governments must act speedily and effectively to improve the environment for business, in order to provide more adequate conditions for world trade growth and satisfy the needs of consumers worldwide.

Keywords: ethics, corruption, governance, economic development, organizations.

NTRODUCTION

Firms engage in commercial transactions in a global macro-environment permeated with very different kinds of relationships, including ethical and unethical practices and outright corrupt ones. In this article the concept of ethics, corrupt practices, which are its most extreme degeneration, and governance mechanisms which aim at controlling and improving business practices were examined. After this first review, a test to investigate the relationships among ethics, governance and economic development were made.

Faced with this situation, countries and organizations are realizing that they must seek to implement governance practices that enable them to become more efficient at attracting resources. Firms also wish to establish successful partnerships, manage their strategic alliances and improve customer perception of their brands, in order to conquer their loyalty and thus increase revenues.

To achieve these objectives, countries must first of all become more efficient at creating the conditions necessary, at both the country and organizational level, to generate a greater volume of business. This concept is referring to the governance of the states, and how it can improve the economic and financial macro-environment, providing organizations with an infrastructure that gives them a competitive advantage in relation to other organizations in markets that do not share such principles.

Therefore, the relations between ethics, governance of the states and the their economic development of these emerging markets were choose as the central issue to be investigated by our research.

Keegan and Green (2000) point out that global marketing activities take place in a political environment of government institutions, political parties and organizations, through which a country's population and their representatives exercise power. Thus it is understandable that all firms are concerned with the political environment and its risks, the efficiency of the judicial system, the quality of regulation, the possibilities of expropriation and the corruption that may permeate business activities in this society.

To achieve this objective, a conceptual framework, involving ethics, governance of the states and economic development were developed, in order to infer possible effects and consequences for the organizations that operate in this environment.

Thus, in the second section, a theoretical framework regards these variables were built.

In the third section, a research methodology that can enable to relate the indicator of ethics, the indicator of the level of governance of the states and indicators of economic development were develop, in order to provide possible links among these variables.

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In the fourth section the results were presented. In the fifth section a discussion of the results were done, in order to generate knowledge that may be of use to organizations in their actions. In the final section the bibliography used for this article were listed.

THEORETICAL REFERENCES

Ethics, according to Stone (2005), discusses what is right and what is wrong, just and unjust, and the issue of duties and rights, on a scale that goes from what is morally acceptable and preferable to what is morally prohibited. However, the extent to which the concept permeates life nowadays is much stronger than could have been imagined some time ago. According to Zajdsznadjer (2001), contemporary society has lost important references to assess its posture regarding religion, science and reason, leaving technology and capitalism in need of something to align and balance them.

Zajdsznadjer (2001) suggests that ethics appears in this context as a tool that can be used to achieve a better quality of life, based on the values of veracity, commitment and care.

Thus this concept, which pervades all human activities, has a particularly strong impact on the financial environment due to the risks associated with unethical actions.

According to Stone (2005), ethics is important in international business for three main reasons. Firstly individuals need guidelines to enable them to identify ethical and unethical actions, and define paradigms to be achieved. The second is that other agents must be induced to adopt the same standards of conduct, which leads to a questioning of the principles adopted by others to fulfill their self-interest. The third objective is to be able to justify the imposition of laws or political actions against those who have not adhered to established ethical standards.

These reasons demonstrate the importance of defining the limits between ethical and unethical behavior. Moreover, according to Dempsey (2000), the ethics of a community impacts the behavior of all the individuals inside and outside this community, through the daily interactions of the business and commercial operations conducted by these individuals.

In the same way, individual and community ethics interact with individuals incorporating the latter's ethics into their way of acting with other citizens, and being influenced by them in their relations with organizations.

Thus, the author concludes that as society develops better ethical frameworks, these values are incorporated into the ethics of institutions. In this way, the development of better standards of ethical conduct on the part of society increases the efficiency of organizations due to a reduction in the occurrence of conflicts of interest.

However, Dempsey (2000) highlights an important perspective on the issue of ethics in organizations, which is that individuals are exhorted to be ethical in accordance with the standards of motivation defined by the organization and not according to their own consciences. Thus profits become a reference for justifying conducts and serve as a parameter for judgments of the limits between the ethical and unethical.

In the perspective of the authors, unethical conduct involves self-serving actions on the part of individuals or organizations aimed at obtaining advantages that flout established rules. This may degrade relations between individuals and organizations and culminate in corrupt conduct.

Thus, corruption is the result of a state of degradation of values, judgments and conducts that, albeit in a simplified form, represents the way a part of society thinks and acts. Therefore the attempt to measure a society's levels of ethical conduct and corruption presupposes the building of a reductionist model that provides only a superficial understanding of such a complex phenomenon.

However, in this article, the objective is to clarify the relationships between ethical and governance actions and their impacts on markets and organizations, and on the latter`s day-to-day commercial relations with their customers. To achieve the goal of this research it is necessary to obtain a clearer understanding of what is meant by acts of corruption, because corruption is the opposite side of ethic.

Corruption involves corruptors and the corrupt in relations that do not conform to prevailing ethical standards in modern societies. Though it is the corrupted party that nearly always attracts the most condemnation, it is the corruptor that plays the most important role in the relationship because he uses economic, financial a political pressures to obtain an illicit advantage.

In this situation, the logic of profit or financial gain leads people to concentrate all the wrath on the corrupted parties, because their acts provoke losses that can be apprehended more easily by the countless societal actors who have lower levels of economic, financial, political or social power. The actions of corruptors, on the other hand, are harder to visualize and require a greater degree of knowledge to be apprehended by the population. According to Zajdsznadjer (2001), that is why some countries and elites limit the access of a large part of their populations to education and culture.

This perspective is confirmed by the information contained in the fourth edition of the United Nations report, “Global Monitoring of Education for All”, that a mere 12 countries concentrate 75% of the world’ illiterate: India, China, Bangladesh, Pakistan, Nigeria, Ethiopia, Indonesia, Egypt, Iran, Morocco, the Democratic Republic of the Congo and Brazil. According to the UN, there is a strong link between adult literacy rates and higher levels of health, income and citizenship.

Transparency International (henceforth only T. I.) has created a rudimentary index that measures existing levels of corruption throughout the world, using assessments of government practices made by executives assembled in world events promoted by the World Economic Forum.

T. I. has published that large-scale corruption in public projects is creating serious obstacles to sustainable development throughout the world, and leading to a significant loss of public funds needed for education, health and social programs, in both emerging and developed countries.

Moreover, according to information from this same organization, the loss of resources due to government corruption amount to around US$ 400 billion a year, worldwide. Thus, according to T. I., corruption, which was formerly considered to be merely a moral issue, has become a more serious threat because of the costs it imposes on the state’s various areas of jurisdiction (social, economic and political). This organization also informs that, despite the biases of the methodology used to calculate the governance index, it is highly correlated with low levels of economic growth and investment, health problems and low levels of education.

Accordingly, reducing the number of cases of corruption, involves adopting legislation to curb illicit persuasion practices throughout the world, and enforcing better rules of corporate governance and compliance codes, to combat corruption in the organizational structure of states.

Thus the methodology developed by T. I. to measure degrees of corruption, involves assessing the role of the constituted powers of the state and their audit systems, the existence of payments of kickbacks to some classes of civil servants, the weakness of civil institutions, and the distorted relations between the state and the private sector. However, and also according to this institution itself, corruption is merely a symptom of the maladjustment of institutions and society as a whole.

In order to share knowledge which it has accumulated over time, T. I. lists some measures and strategies that have been adopted by countries all over the world, to mitigate and prevent corruption.

In this context, one can understand how important it is to choose principles and values than can enable a more favorable environment to be created for the development of relations between individuals and organizations, especially in the business sphere. The establishment of rules and conditions for the development of an environment that fosters ethical conduct, and therefore discourages corruption, is one concern of corporate governance.

Governance practices can make an important contribution to reducing levels of corruption, and are based on four fundamental concepts: the equitable treatment of individuals; transparency of entrepreneurs’ and regulators’ actions; the responsibility assumed in executing certain tasks and achieving objectives; and the respect for laws, rules and forms of conduct that are acceptable to society.

Having seen that many suggestions of measures to reduce levels of corruption in business and increase ethical behavior, directly or indirectly, involve concepts related to governance, it is necessary to define the concept of the governance of the state more clearly, and ascertain the impacts it can have on both the macro and micro business environments.

Kaufmann (2005a) showed that governance of the state is an extremely complex variable which includes countless perspectives, and by not defining a specific set of characteristics, anyone is able to construct various indicators, allowing several different analyzes to be made.

However, Kaufmann, Kraay and Mastruzzi (2003) expanded Kaufmann, Kraay and Zoido-Lobatón’s (1999a, 1999b and 2002) definition of the components that should be measured and analyzed in order to construct a country’s governance index, and listed the following groups of subjects that should be investigated to construct a indicator of the governance of the state: a) voice and accountability; b) political stability and absence of violence; c) government effectiveness; d) regulatory quality; e) rule of law; and f) control of corruption. In order of being referring to items that constitutes a more comprehensive index of governance, it is appropriate to inform that in this research, the item government effectiveness was used to represent the variable governance of the state.

According to Kaufmann (2005), the state's capture may also be linked to the creation of obstacles to its reform and modernization, which is designed to make it more efficient and thus better adapted to the demands of a dynamic global economy. Moreover the state's degree of transparency and competitiveness forms a dividing line that separates normal lobbying from acts of corruption.

In general, elites capture the state by:

- Purchasing legislators' votes in decision relating to their interests;
- Purchasing decisions emanating from the executive and judicial branches;
- Influencing the regulations of the financial and political systems;
- Illegal financing of election campaigns.

We also understand that it is possible to define the governance of a country in a much broader way, by establishing a parallel with the concepts developed by La Porta, Lopes-de-Zingales and Schleifer (1998) for the private sector. Thus one can define it as the group of voluntary practices adopted by societies and their representatives, in order to better control political and financial risks (related to the country's administration and possibility of default), but which also involve a more equitable treatment of the population's interests and the achievement of an increasing trend of economic and financial development.

Using the indicator developed by Kaufmann, Kraay and Mastruzzi (2003), and relating it to the wealth indicators of various countries, the authors concluded that there is no general link enabling one to associate good governance practices by the states with rich countries and bad practices with poor ones.

Similarly, they also found that it is not appropriate to assess the quality of the governance of the state in terms of its compliance with certain legal standards. Regarding this point, the authors mention that most countries' elites grasp the power to dictate the rules of the game.

Still with respect to the quality of governance, the author states that it is extremely important to examine the practices of transnational and domestic firms in order to define ethical standards in business. In this context, it seems clear that the private domestic and foreign sectors intertwine in day-to-day commercial operations with the public sector, in which the latter either reproduces or initiates a process permeated by a lack of ethics, transparency or equity, especially in emerging markets.

Thus, using empirical data from the surveys of executive opinion carried at events organized by the World Economic Forum, some authors like Kaufman (1997 and 2005) and Kaufman et al. (2002 and 2005) were able to make an initial analysis of these variables on a worldwide basis.

With respect to problems regarding the consequences of bad governance practices on part of the countries, the World Bank's 2005 Equity and Development report, makes it clear that in order to fight poverty, and therefore violence, more efficiently, it is fundamental that societies better operationalize the concept of equity, understood as "equality of opportunity for people". In order to do this, it will be necessary to increase the poor's access to health, education, job, capital and land property rights, by providing more equal access to political freedoms and public authorities, and also eliminating stereotypes and improving access to judicial and infrastructure systems.

Thus, it is possible to see that the globalization of business has increased concerns with ethics, corruption and governance practices, and it is important to point out that the globalization process has created a network of links between countries' economic, political, social and cultural facts. Because of this, it is impossible to exclude aspects related to business ethics, governance mechanisms and forms of corruption from the list of issues embraced by the globalization process, just as one cannot deny that there is a strong conceptual relation between these variables and the development of organizations and therefore countries.

To improve the business environment, it is absolutely essential to improve the quality of governance of the states.

In order to achieve a better understanding of our argument so far, a conceptual model in which ethics and governance are related to a society's level of economic development was constructed. Its broad conception was intentional, in order to allow future research to widen and deepen possible relations, by carrying out an empirical investigation of the phenomenon using more complex models.

Conceptual Model:

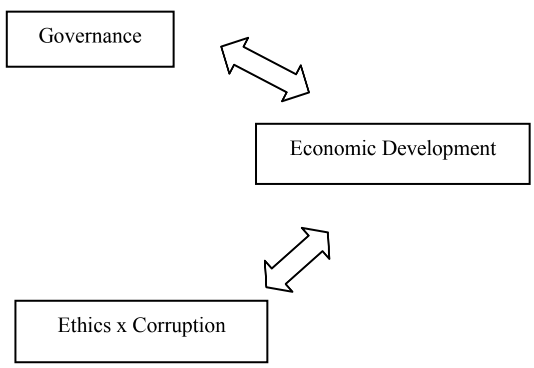

Fig. 1. Source: The authors

RESEARCH METHODOLOGY AND ANALYSIS OF THE DATA

This research is of an exploratory nature and follows a neo-positivist epistemological approach, seeks to understand the relationships among ethics, governance of the states and economic development in a sample of relevant markets, in order to be able to develop some generalizations regarding their situation.

Secondary data were obtained from the World Bank and Transparency International websites to provide a basis for our empirical investigations.

Economic, financial and social data were selected from the World Bank website to construct the empirical database shown in this article. At this website we found economic and financial data for the period 2002 to 2008.

To construct this sample, all those counties with large domestic products that possessed indicators for all the variables selected to represent countries' economic development were included.

Empirical data relating to ethics, governance levels and economic variables of 54 countries were included, in order to assure the statistical significance of the results. As the principal goal is to establish a conceptual model, the method of structural equations was used to get some inferences among the variables.

The concepts, the variables and the indicators used in this research are listed in table 1.

Table 1 - Concepts, variables and indicators

CONCEPT (ATTRIBUTE)	VARIABLES	INDICACTORS OF VARIABLE
Ethic levels of the states	Corruption	CPI Index as measure by Transparency International (CPI)
Governance levels of the states	Government Effectiveness	Levels of government effectiveness per year of each country (GOV EF)
Sustainable development	Economic and financial development	Levels of GDP growth per year of each country (GDP GR)
Sustainable development	Economic and financial development	Levels of Gross Capital Formation per year of each country (GCF)
Sustainable development	Economic and financial development	Levels of income *per capita* per year of each country in power purchasing parity (INC PC)

The universe for this study is composed of 228 countries. The focal sample includes a set of 54 countries. To construct this sample, countries were selected that have available more than 70% of the data surveyed in the years under investigation. Table 2 shows the countries that make up the sample.

Table 2 - Countries of the sample

Countries in alphabetical order (1 to 10)	Countries in alphabetical order (11 to 20)	Countries in alphabetical order (21 to 30)
Angola	Czech Rep.	Hungary
Argentina	Denmark	India
Australia	Egypt	Indonesia
Austria	Ecuador	Ireland
Belgium	Finland	Iceland
Brazil	France	Israel
Canada	Georgia	Italy
Chile	Germany	Japan
China	Greece	Malaysia
Colombia	Hong Kong	Morocco

Countries in alphabetical order (31 to 40)	Countries in alphabetical order (41 to 50)	Countries in alphabetical order (51 to 54)
Mexico	Portugal	Ukraine
Mozambique	UK	Uruguay
Netherlands	Russia	USA
Nigeria	South Africa	Venezuela
Norway	South Korea	
New Zealand	Spain	
Pakistan	Sweden	
Paraguay	Switzerland	
Peru	Thailand	
Poland	Turkey	

3.2- Hypothesis

The hypotheses to be tested in this research are as follows:

H1: The relationship between ethics, as measured by the C.P.I., and potential for economic development, as measured by levels of GDP growth will be positive;

H2: The relationship between ethics, as measured by the C.P.I., and potential for economic development, as measured by levels of Gross Capital Formation will be positive;

H3: The relationship between ethics, as measured by the C.P.I., and potential for economic development, as measured by levels of income per capita will be positive;

H4: The relationship between governance, measured by the Governance Effectiveness index, and potential for economic development, as measured by levels of income per capita will be positive;

H5: The relationship between governance, measured by the Governance Effectiveness index, and potential for economic development, as measured by levels of income per capita will be positive;

H6: The relationship between governance, measured by the Governance Effectiveness index, and potential for economic development, as measured by levels of income per capita will be positive;

H7: The relationship between ethics, as measured by the C.P.I., and governance, measured by the Governance Effectiveness index will be positive;

3.3- Model used in this research

To determine if there are relationships among ethics, the level of governance of countries and economic and financial variables of the states, the method of structural equations was employed. The schematic summary of the equations is

$$CPI = f(GOV\,EF, GDP\,GR, GCF, INC\,PC)$$

$$GOV\,EF = f(CPI, GDP\,GR, GCF, INC\,PC)$$

$$GDP\,GR = f(CPI, GOV\,EF, GCF, INC\,PC)$$

$$GCF = f(CPI, GOV\,EF, GDP\,GR, INC\,PC)$$

$$INC\,PC = f(CPI, GOV\,EF, GDP\,GR, GCF)$$

RESULTS

After applying the method of structural equations, the following results showed at table 3, were observed.

Table 3 - Data were presented with their p-values. The symbol *** represents a statistical significance of 0,001%; the symbol ** represents a statistical significance of 0,01% and the symbol * represents a statistical significance of 0,1%.

Variables	Covariances and p-values
CPI ↔ GOV EF	0,278* (0,026)
CPI ↔ GDP GR	- 0,557** (0,007)
CPI ↔ GCF	- 0,266 (0,425)
CPI ↔ INC PC	28.417,572*** (0,000)
GOV EF ↔ GDP GR	0,291* (0,076)
GOV EF ↔ GCF	0,253 (0,347)
GOV EF ↔ INC PC	1576,795* (0,013)
Number of observations	454
RMSEA	0,237 (0,000)
λ^2 (Chi square)	83,165 (0,000)
Degrees of freedom	3
Number of parameters	5

DISCUSSION OF THE THEME

On a conceptual plane, it was possible to verify that ethics and governance level of the states are extremely important as driving factors behind business and economic development. These concepts are related to the way countries manage to control unethical actions such as those involving corruption.

In a broader sense, countries with better governance indicators and higher ethics indicators provide more appropriate conditions for economic development. However, as Kaufmann, Kraay and Mastruzzi (2003) predicted, the covariance between CPI and GDP GR was negative and with statistical significance. So, it is possible to associate states with higher levels of ethics with states with lower levels of GDP growth and vice-versa.

By the other hand, higher levels of governance, as measured by government effectiveness, are associated to higher levels of GDP growth. So, it is possible to infer that states with lower ethics levels but with higher govern effectiveness are increasing with higher levels of GDP growth. This can means that countries with large GDPs and high growth rates may have more corruption simply because they have a greater volume of transactions, and because growth may conceal actions of corruption and economic efficiency, leading to a decline in the level of perception of internal problems.

Kaufmann and Kraay (2002) prove that there is strong and positive relation between the improvement in levels of governance and increases in countries' per capita income as it was possible to identify in the covariance between GOV EF and GNI PC, and its statistical significance.

However it was also possible to see that higher levels of governance and ethics are positively related to higher income per capita, and therefore more equitable conditions and a greater economic and social growth potential.

Thus it is possible to verify that in order to improve the business environment it is necessary to improve governance, reduce corruption and establish ethics firmly in contemporary mankind's transactions and mindset.

Therefore in the current context, it is fundamental that equitable and transparent conditions prevail, imbued with a respect for laws and rules, and in which business is conducted by responsible and ethical individuals.

Only in this way will organizations prosper in the environment of sustainable peace and possible world equilibrium which are so important for the planet's citizens and sustainable growth. Similarly, Fort and Schipani (2005) affirm that transnational and multinational firms can contribute to sustainable peace by changing the way they exercise power. This means improving their governance practices, and especially being more equitable, so as to become agents in the quest for a more democratic society in the places where they operate.

Though, according to Moshirian (2003), one may easily observe that national and international institutions all over the world have been finding it increasingly difficult to contain an escalation of insecurity and threats to peace, and promote the kind of economic growth that respects global human needs.

In our opinion, there is a quasi consensus that the structures that have not accompanied the change in the global business environment will have to be reformulated. However, it is not so much new structures that are needed, for they are merely instruments, as fresh forms of thinking and acting, fresh values and a complete understanding of human needs.

Fundamentally what is needed is not just to understand today's world (a rational process), or understand problems (put oneself in the other's place and feel), but a kind of "understanding-acting" that leads to the creation of a new way of perceiving and living. Thus it is vital to recover a sense of ethics, and that the acts of states, organizations and individuals be in accordance with the best possible conscious governance practices.

There is a group of global needs (ethics and governance) that corporations and institutions must meet in order to maximize the global customer's satisfaction. To achieve this they must use global marketing to establish a link between their business and institutional activities and the global citizen.

To conclude, other researchers can further investigate the conceptual link between these variables, by including other values in the conceptual analysis, in order to build a better theoretical framework, which can be used to explain the relation between best country governance practices and economic development.

Furthermore, a good way to achieve a more comprehensive knowledge about the relationship among these variables is to try to find other performance and governance indicators, in order to increase the understanding of the phenomena that have been investigated in this article, in an exploratory fashion. Another suggestion for future studies would be to insert one or more corporate governance indicators in the countries of a future sample, in order to analyze their relation with economic development.

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ON THE LIMITATIONS OF GOVERNMENT SPENDING

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Abstract: Budget deficit and the nexus between tax and spend has been a subject of debate for centuries and constitutes a classical problem of Public Economics. However, government spending through debt, its long run effect and sustainability is, recurrently being addressed now as many countries are reeling under debt crises. This discussion is crucial since it has several implications on the size of government, level of budget deficit, and structure of taxation and expenditure. Bearing this in mind, we provide in this paper a discussion on the (i) tax-and-spend, (ii) spend-and-tax and (iii) fiscal synchronization policies. More specifically, we debate their intrinsic relationship, effect on aggregate demand, employment (Keynes), liability (Ricardian Equivalence), long run effect and sustainability. The paper in its debated perspective finally addresses a discussion into deficit economy of India, an emerging market.

Keywords: Economic; public_sector; sustainable_growth; turbulent_enviroment; tax_compliance_efficiency; Governmence

INTRODUCTION

In all forms of world economy, the relationship between government revenue and government expenditure is crucial, given its relevance to the policy makers with respect to budget deficit as its effect has a causal relation with the participating members – the electorate ([1]). The causality between revenue and expenditure especially the direction of this causality may have direct impact on the economic growth of a country. Essentially, it may determine the nature of the growth – endogenous or exogenous or both – resulting in long term sustainability.

Budget deficit and the nexus between tax and spend is a classical problem of Public Economics and has generated a huge cross-country debate in literature.

Specifically, in a federal country like India, where sub national governments (SNG's) rely on central transfer in presence of vertical inequality, this is an issue that can hardly be overstated. In fact, if the SNG's anticipate that, in moment of fiscal crises, a weak central authority will bail them out through lump sum transfers that will generate perverse incentive to generate a deficit at the sub national level through lower local revenue. The consequence: SNGs accumulate large debts and increasingly rely upon the central assistance. This leads to spend and tax principal of framing the budget and if the GDP growth is not stimulated by such spending above the interest rate the debt trap arises. On the other hand, if, in an effort to synchronized state of budgeting, the government increase the taxes and causes a cut in the social expenditure the economic growth is adversely affected ([2]).

This paper focuses on the causal relationship between revenue and expenditure (Section 2) and specially addresses the case of India (Section 3). The main conclusions are finally addressed in Section 4.

THE CAUSAL RELATIONSHIP BETWEEN REVENUE AND EXPENDITURE

There are three main fundamental principles of framing a budget: (i) tax and spend; (ii) spend and tax and fiscal synchronization hypothesis.

Tax and spend hypothesis states that is the revenue which leads and controls the spending decisions. This school of thought believes in the notion that raising taxes will lead to more spending. Ref. [3] has argued that if the government adjusts expenditure to revenue the endogenous growth of the economy (GDP) may be further inhibited causing further deficit.

As opposed to this theory, the spend and tax principle postulates that is actually the expenditure which causes the revenue. It assumes that deficit financing is an important fiscal instrument to boost employment, consumption, saving and production. Moreover, the revenue inflows are determined by increasing taxes.

Last, the fiscal synchronization school of thought believes that the relationship between tax and expenditure is bidirectional. The fiscal synchronization is observed to the extent where changes in expenditure are balanced by simultaneous taxation. This hypothesis was propagated by Ref. [4], which has lent support to this principle.

Many studies have investigated the nexus between the government revenue and the government expenditure. The empirical evidence is, however, mixed. For instance, while Ref. [5] found, in case of a long-term US debt, evidence of a long bi-directional causality between revenue and expenditure lending support to the synchronization theory, Ref. [6] reported two distinct causal structures in the US post war era: (i) before the mid-1960's, taxes appear to cause spending; (ii) after the late 1960's, taxes and spending are causally independent. A more in-depth analysis was performed by Ref. [7], who has examined the temporal relationship between revenues and expenditures for the forty-eight U.S federal states over an annual period spanning from 1942 to 1992. An examination of each state was conducted in order to avoid the possible aggregation problem reportedly, associated with the data used in earlier studies. Using an error-correction model, the study have fond that the tax and spend hypothesis was supported by twenty-four states. The spend-tax hypothesis was valid for eight states while the fiscal synchronization hypothesis was supported for eleven states. The remaining five states failed the diagnostic test for error-correction modelling.

Recently, the intertemporal relationship between US federal government expenditure and revenue was also investigated by Ref. [8]. It was pointed out that the impact of tax cut generally does not result in decrease in spending, which invariably rises due to the perception by the public of a lower cost of the government raising his expectation on public goods. This perception is augmented by the increase in spendable wealth with the public. Thus, the ultimate goal of an eventual cut in the spending is not achieved. The study propagates the fiscal illusion theory sighting negative functionality between spending and tax. A tax increase makes people resistant towards the government spending. The fiscal Illusionist encourages tax increases during times of budget deficits to make the public aware of the costs and lower their expectation. The paper suggests that tax increase – even temporary – may serve to decrease expenditure by forcing public to recognize the cost of the government spending. The paper is indicative of a negative causality between tax and spend.

Further evidence on spend and tax hypothesis for the US was also provided by Ref. [9], which has investigated the nexus between government expenditure and revenue for the period 1955-1981. Similar conclusions were provided by Ref. [10] but for the period 1945 to 1981. Distinct conclusions have arrived Ref. [11] who has found that revenue causes expenditures in US. Additionally, Ref. [12] has found support of fiscal synchronization for the same country.

The debate on tax and spend, spend and tax or fiscal synchronization does not, however restricts to US; but has extended to many other countries, in an attempt to test which one of these hypothesis prevail. In this line, Ref. [13] has conducted a study on the G7's country using cointegration and error-correction model. The empirical results show that bidirectional causality exists between government taxes and expenditures in all countries except in Japan and Italy. For Japan and Italy, causality runs from government taxes to expenditures. With a similar aim Ref. [14] has focused on nine industrialized countries. The authors have chosen the countries keeping in view the country's approach to public financing concerning the redistribution objective *vis a vis* the general economic support and the respective political under tones, objectives and attitude. The empirical findings strongly support the spend and tax view that budget decision-making was significantly dominated by the expenditure in Italy, Austria and France. The opposite (tax and spend hypothesis) seems to be true for U.K., Netherlands, Germany and U.S. For Switzerland and Sweden neither of the approaches is apparently applicable.

Subsequently, Ref. [15] has examined the causality between taxes and expenditures for eight Latin American countries. The findings of bidirectional causality between taxes and expenditures in Chile, Panama, Brazil, and Peru indicate that taxes and expenditure are jointly determined – the synchronisation hypothesis holds. This study, however, detects causality running one way from taxes to expenditures in Columbia, Dominican Republic, Honduras, and Paraguay, which upholds the view that more taxes only induce more expenditure. Nevertheless, this does not imply that lower taxes mean lower expenditure because the government might opt for debt financing rather than tax financing. Interestingly, the authors opine that the evidence obtained from the eight Latin American countries flatly rejects the Barro's contention (RE- Ricardian Equivalence) that increased expenditures cause higher taxes. Taken together, this study strongly rejects the spend-and-tax hypothesis for the eight countries.

Following the same cross-country analysis Ref. [16] has tested the 'Tax-and-Spend', 'Spend-and-Tax', and 'Fiscal Synchronization' for 10 countries using annual series over the period 1951-1996. Three of them are part of the newly industrialized countries of Asia (South Korea, Taiwan and Thailand) and seven are industrialized countries (Australia, Canada, Japan, New Zealand, South Africa, UK and the USA). The results suggest unidirectional causality running from revenues to spending, supporting the tax and spend hypothesis for Japan, South Korea, Taiwan, UK and the USA. The opposite relationship, supporting the spend and tax hypothesis, holds only for Australia and South Africa. In the case of Canada, a feedback between revenues and spending was found, supporting the fiscal synchronization hypothesis. For New Zealand and Thailand, these results support none of the hypotheses.

Furthermore, Ref. [17] has investigated the sustainability of the Swedish fiscal policy performed during the period 1963-2000. The main emphasis of the study was on assessing the effects of changes in fiscal policy, such as, changes in taxes or public spending. The results show that taxes and spending are causally related in the long-run and that the homogeneity condition is empirically supported. For the entire period, the hypotheses of bi-directional causality cannot be rejected, which provides an empirical basis for the view that spending changes simultaneously with revenue in Sweden.

Ref. [18] has investigated the causal relation between government revenue and government expenditure for nine Asian countries. The authors have used the recently developed bounds testing approach to cointegration and the conventional F-test to examine the Granger causality. The empirical results suggest that for: (i) Indonesia, Singapore, Sri Lanka in the short-run and for Nepal in both short and long-run the tax-and-spend hypothesis holds; (ii) Indonesia and Sri Lanka are in conformity with the spend-and-tax hypothesis in the long run; and (iii) for other countries there is evidence of neutrality.

In Ref. [19] for the period 1957-93, the relationship between government spending to GDP for Greece has been studied, and it establishes that reduction in deficit may not be achievable without drastically reducing the government spending. In a similar study for Malaysia, an emerging economy, Ref. [20], establishes a bi-directional causality between government spending and tax revenues. Ref. [21], a study for Mauritius, a well-doing small island economy, establishes synchronization state of planning. Studies for Africa, talked of as the continent of the future, are sparse. Ref. [22] studies the fiscal policies of Namibia and establishes a unidirectional causality from revenue to expenditure despite deficit budget. For the Swiss federal fiscal policy, one of the most stable present day economy, Ref. [23] establishes a bi-directional causality between federal revenues and expenditures.

The above-mentioned literature highlights the relevance of the subject as well as provides an overview of the state of the art ongoing research on the subject. It seems that while tax and spend relationship is a common theme a consensus concerning causality has yet not been reached. At times, taxing appears to cause spending, but over other periods spending seems to drive taxing, while in others taxing and spending simply appear autoregressive. In such an empirical setting a point of policy control remains an open question ([24]).

The review in this Section aims to introduce the role of the budget framing process into the empirical literature and addressing the impact of tax-spend relationship.

THE CASE OF INDIA

This Section addresses the Indian economy in the light of the tax and spend relationship. Ref. [2] has studied this nexus for 14 major states of India and has concluded for the directionality from expenditure to revenue in addition to the fact that electoral cycles have their effect on the nature of the expenditure. In India the Central Government‘s Fiscal Policy has a significant effect on the GDP growth as Government is a major player in aggregate expenses, and also frames and determines the economic policies [25].

While the literature on the theory of budgeting is rich in all its aspects of analysis, however, the impact on the economy has not found much of quantification. The authors have addressed this requirement by studying the impact of the budget on the growth of the economy from a non-traditional, unique concept of boardroom trend analysis and place it in the economic domain for discussion extending into cross-country analysis on similar concepts. The support data for this analysis have been sourced from Refs. [26]-[27].

Table 1 gives a brief overview for the Indian economy. It is evident over these last forty years there has been a significant growth in the Indian economy in nominal terms. The total revenue receipt has increased by 158 time in relation to 1970 from a meager Rupees 0.046 to 7.27 billion. For the same period the expenditure has increased 197 times, from Rupees 0.056 to 11.09 billion. In consonance with these increases the fiscal deficit has increased by 270 times from Rupees 0.0141 to 3.81 billion. The deficit has outpaced the growth in the revenue receipt by more than 1.70 times. The cumulative deficit has grown 2206 times in these 40 years. However, in the same period the external liability has grown only 13 times. This reflects that the main borrowing is internal in nature and thus the economy has had no major hiccups during the downturns in the international economies.

Table 1. Some figures on India economy

Year	1970	2010	Growth
Total Revenue Receipts	3,293	682,212	207.17
Total Capital Receipt	1,297	45,129	34.79
Total Receipts	4,590	727,341	158.46
Total Revenue Expenses	3,130	958,724	306.30
Total Capital Expenses	2,494	150,025	60.15
Total Expenditure	5,624	1,108,749	197.15
Fiscal Deficit	1,408	381,408	270.89
Cumulative Liability ex deficit	1,408	3,107,138	2,206.77
External Liability	12,328	162,045	13.14
Interest Expense	606	248,664	410.34
GDP (at constant price) basis 1999-2000	451,496	4,168,917	9.23
GDP (at Market Prices) basis 1999-2000	491,798	4,807,222	9.77
WPI Calculated Index if base remains 1970-71	100.00	1,841.29	18.41
CPI at base 1970-71	189.00	3,519.00	18.62
Gold Prices Rs per 10 gms	184.96	20,496.00	110.81
Silver prices Rs per kg	536.08	37,084.00	69.18
1$/Rupee	7.50	45.00	6.00
SDR/Rupee	7.50	78.00	10.40

Source: Government of India budget publication and Reserve Bank of India publications (numbers in Rs × 10 million)

Moreover, we have calculated the deficit quotient as a ratio between the deficit and the total expenditure. Fig. 1 depicts this quotient.

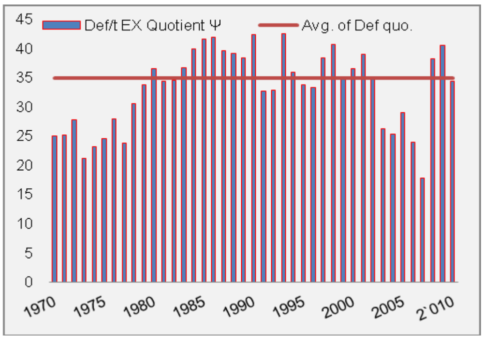

Fig. 1. Trend of the deficit quotient

The quotient is consistently over zero-balanced budget, maintaining an average of 34-a deficit budget, for the period. The continuous attempts by the fiscal planners to lead to the synchronization concept are also evident from Fig. 1, except for the initial years. However this attempt has been undermined by a significant rise in the quotient after a lag period of normally, 2/3 years. It is clear from Fig. 1 that the Government is obliged to spend continuously more than the revenue possibilities, ultimately following a spend-tax policy, meeting the needs through borrowing.

In the spend-tax environment the nature of the expenditure is significant as the Government spends with an expectation to cause GDP growth. Fig. 2 shows the capital expenditure and deficit as a ratio of total expenditure.

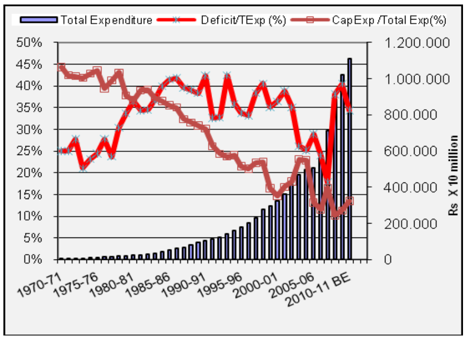

Fig. 2. Percentage of deficit and capital expenses to total expenses

The trend line crosses the equilibrium in 1983-1984. This reflects that up to the equilibrium, it could be taken that the borrowing was supporting capital expenses. However, since then it is clear that deficit is supporting the revenue expenses of the government the ratio of capital expenses to total expenditure is significantly declining. This highlights the presence of spend-tax principal, where the government is sourcing its revenue expense in debt rather than in its present day income transferring the debt responsibility to the future. Such spending tends to generate a crowding out effect on the GDP growth.

In the decade of 2000-10, the government has opened up the fiscal policy for Foreign Institutional Investments (FII) in the capital markets, Foreign Direct Investments (FDI) in majority of the manufacture and service sectors, resulting in increased liquidity in the market, causing increase in aggregate demand. While the GDP average growth for the period 1970-2010 is 5.8% per annum, it stands at 8.41% and 9.78% for the last 10 years and 5 years respectively.

The impact of this exogenous growth is a subject of our further study, from the view of its sustainability while recognizing the spill over effect of the technology, human capital and the demand on the endogenous growth. The study of the causality among the variables deficit, GDP, WPI and CPI are also under investigation by the authors in consonance with the exogenous effect of the FII and FDI. Fig. 3 illustrates the trend line of total revenue, total expenditure and the percentage of the GDP growth for the period 1970 to 2010.

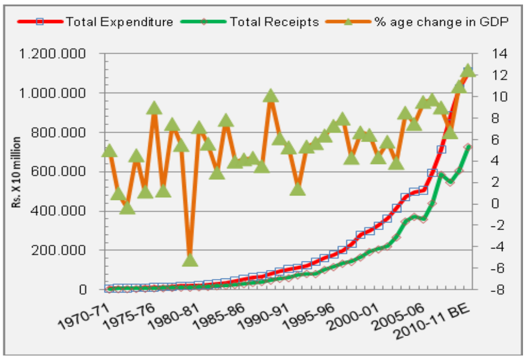

Fig. 3. Trend of Total expenses and income *vis-a-vis* GDP growth

In the Keynes' perspective, the government expenses increase aggregate demand, causing growth in GDP leading to full employment. Considering this hypothesis, we have studied to establish for the last ten years (the best period of economic growth), the GDP growth required at a time t to cover the deficit keeping the tax in other words the percentage of GDP as revenue, collection rate constant. We have then extrapolated, based on these assumptions, for the last ten years and calculated the total GDP growth required at a time t to cover the cumulative liability of the government. Fig. 4 gives the trend line.

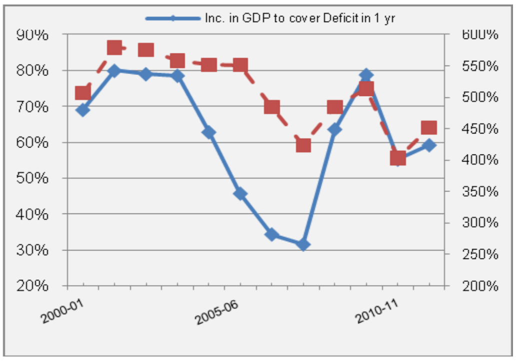

Fig. 4. Increase in GDP needed to cover deficit and total liability

At any given time t GDP will need to increase by more than 60% (avg) to meet the expense requirement at time t. By same logic to show enormity of cumulative debt situation we have calculated on theoretical assumptions, a requirement of more than 600% (avg) growth in GDP to redeem the total debt at a given time t. The increasing debt cycle leading to a debt trap is evident.

According to Ricardian Equivalence, *prima facie*, today's borrowing is tomorrow's tax. Ref. [28] has invalidated the Ricardian Equivalnce for the period 1950 to 1986, for a less developed country, India. However the annual deficit budget continues with cumulating effect on the liabilities. Therefore, keeping the GDP constant, as at any given time t the GDP cannot be changed suddenly, whereas the taxes can be changed by the Government decree. We have estimated the percentage of GDP required as income to cover the deficit at a time t and then extrapolated to calculate the shortfall between the required and actual receipt. These results in form of trend lines are reflected in the Fig. 5.

The shortfall between the actual and required receipt is consistently at about 60% (avg) of the present receipt, *i.e.*, all applicable taxes will have to be raised by about 60% uniformly at constant GDP.

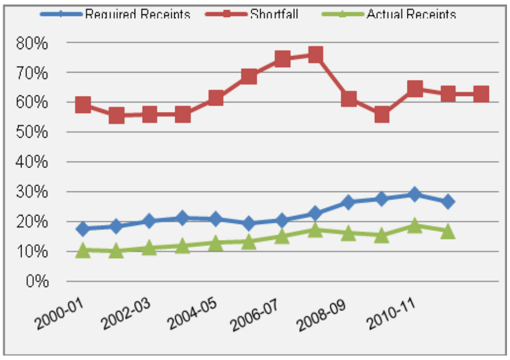

Fig. 5. Trend line showing required Receipts *vis-a-vis* actual receipts and shortfall

With the cumulative liability standing at 31 billion Rupees against the revenue receipt of Rupees 6.82 billion in the year 2010, the debt trap is obvious and is increasing at a consistent debt coefficient averaging at around 34 per year.

Yet, the economy is showing tremendous sustainability, apparently due to two fundamentals: (i) firstly the primary source of debt is the nationalized banks, small savings, old age pensions, life insurance and other financial institutions in the public (Government) sector, thereby the call on money is virtually absent; (ii) secondly, the effect of FII and FDI causing liquidity in the market and increasing the aggregate demand.

However, the FIIs and the service sector are leading in investments creating an exogenous effect on the GDP. The sustainability of these investments and its impact on inflation is presently a subject of concern.

We have debated the Indian Fiscal Policy on the erosion or the loss of money value of the Rupee. Taking into consideration the average interest rate on deposit in bank at 7.49%, increase in CPI 18.62 times and the income tax at the rate of 20% (mid rate) on the interest earning at the time of redemption the loss of buying power calculates at 21.69% for the period of investment, 1970 to 2010. Calculated over the period, the retained value of the investment of Rs100 comes to Rs. 78.31 at constant prices of 1970. The erosion is highlighted in the Fig.6. In India, long term bank deposits are considered safe compared to institutional bonds and share market investments.

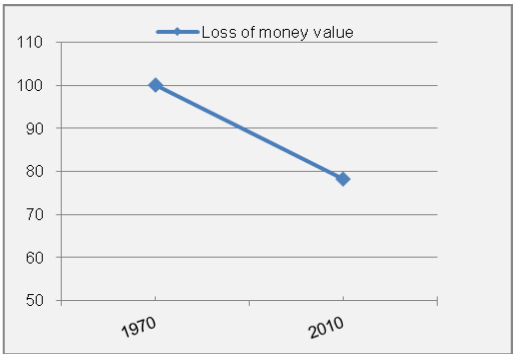

Fig. 6. Loss of money value

This erosion of the net worth forms an interesting subject of further study.

CONCLUSIONS

The study concludes that the literature review in this paper has amply highlighted the important significance of the nexus between the Government Revenue and Expenditure. The detailed analysis will show that for the same country the directionality and interdependence may not be constant for all times.

Nevertheless, the finding of significance from the literature review shows that most of the countries over the years have been planning a deficit budget. Even though the fiscal planners in India may be trying to find new sources for generating revenue and follow the fiscal synchronization hypothesis for attaining a balanced budget, the bi-directional or the tax and spend hypothesis is not perceivable in the present trend of fiscal policy. Expenditure is leading; debt is cumulating. In terms of RE, the question arises, is the fiscal policy, over the years of study, sacrificing the future for the present. The electorate not being aware of the cost of the government are habitually demanding more and more public services and goods, financed by debt resourcing Ref. [8].

In continuance of this paper the sourcing of debt and the causality between deficit financing and CPI, GDP and erosion of the value of the rupee brings out interesting challenges for further studies. The effect of the exogenous influence on the GDP adds a further new dimension to this study.

Despite the insight given in this study, to fully understand the impact of the fiscal policy on the federal economy of India, specially the causal effect of a deficit budget on economic growth and erosion of the net worth, further research is ongoing.

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HEURISTIC METHODS FOR PROCESS OPTIMIZATION IN THE AUTOMOTIVE INDUSTRY

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Abstract: In this paper we address a real leather nesting problem (LNP) arising in the component industry of the automotive sector. We describe two approaches for the resolution of the LNP. The first approach consists in a constructive heuristic, while the second relies on local search methods. The constructive heuristic is based on a simulation of the positioning of a piece so as to evaluate its fitness within the hide and within the current layout. The local search method operates in cutting patterns. We describe also an improvement of our constructive heuristic in order to apply it at each iteration of the local search procedures. The proposed models were implemented and tested in real instances of the automotive industry. The results illustrate the adequacy and the potential of the proposed approaches.

Keywords: Decision support systems; Heuristics; Enterprise applications; Tools

INTRODUCTION

The Nesting Problem (NP) consists in determining the best way to place a set of small irregular objects within a regular or irregular surface. The NP is a combinatorial optimization problem. More precisely, it is a cutting and packing problem. The NP arises in many industries like footwear, the production of car seats and the textile industry. A key distinctive characteristic of cutting and packing problems is that any small object that is placed in the surface must be completely inside this surface, and such that the objects do not overlap with one another.From this point forward, the small objects will be denoted by pieces. The pieces must be placed on the surface so as to optimize a given objective criterion. Usually, this objective consists in the minimization of the waste that is generated in the cutting process.

The shape of the surface is an important factor for the analysis of the NP. If the surface is irregular, the problem becomes even more complex. However, if the surface is regular, the simplification of the NP happens only at an early stage: each placement of a piece may add some irregularity to the contour of the current layout which defines the border of the feasible placement region.

Another important factor is the nature of the surface. The surface can be homogeneous or heterogeneous. The difference between both in terms of complexity is that the heterogeneous surface has additional placement constraints.

The irregularity of both the surface and objects that have to be placed increases the complexity of the placement problem. To deal with the geometric aspects of the NP, many different techniques can be used [1]. The objective of all these techniques consists in evaluating the relative position of different pieces. In this work, we resort to one of these techniques, namely the No-Fit Polygon (NFP) strategy.

The NFP is the polygon derived from the combination of two polygons in such a way that the interior of the NFP represents the set of points of intersection between these two polygons. The edges of the NFP define the set of points in which both polygons are in contact but do not intersect. The exterior part of the NFP represents the set of points in which both polygons are not in contact [1]. Note that the obtained polygon is valid only if the pieces keep the orientation which was used when the NFP was computed.

NESTING PROBLEMS IN LEATHER HIDES

The NP in leather hides is known in the literature as the Leather Nesting Problem (LNP).

Besides the fact that these surfaces are not homogeneous, the leather hides have defects and holes resulting from its nature or from the extraction process. According to Wascher et al. typology [2], the LNP belongs to the class of two-dimensional residual cutting stock problems.

Very few contributions on the LNP are reported in the literature. One of the first dates back to 1995, and is due to Heistermann and Lengauer [3]. These authors proposed a constructive heuristic for the LNP with quality zones and defects. Their heuristic divides the hide into a live region and a dead region. The distinction between both is that the former is available to place pieces. The algorithm runs while there is a live region and while there are still pieces to place.

In [4], Yuping et al. proposed a very fast simulated re-annealing method for the LNP. This method enables a fast decrease of the temperature. The authors compared their results obtained with their method and the manual placement of the pieces done by the operators. The latter approach has duration of 15 to 30 minutes, with an average utilization of 70%. The authors report an average utilization is 75.5% for an average execution time of 29 minutes using their method.

In [5], two methodologies were proposed to implement a genetic algorithm for the NP in the footwear industry: one of the strategies is based on local placement, while the second on a concept of connectivity. In the former, the pieces are placed based on the calculation of the intersection points among the no-fit polygons. More recently, a new method based on simulated annealing and genetic algorithms was proposed in [6] and applied in the production of car seats. In this approach, the layouts are built using a simple bottom-left strategy.

As stated, there are a few works in the literature about the NP in irregular surfaces. The lack of approaches is felt both at the scientific level and production level. In this paper, we analyse the variant in which the surface has an irregular shape, holes and heterogeneous quality zones.

CONSTRUCTIVE HEURISTICS IN THE NP WITH IRREGULAR SURFACES

Constructive heuristics have been applied to the resolution of NP by many authors because of the fast and good approximations that they can provide [7]. In a constructive heuristic, after a piece is placed, it is not possible to change its position or orientation. Usually, constructive heuristics are divided into the following steps: pre-processing, grouping the pieces, sequencing the pieces, select the next piece to place, select a placement region and post-processing.

A production order is composed by pieces of many types and each type has an associated demand. In our approach, the types of pieces are divided in groups. These groups are sorted by decreasing order of area of the pieces included in each group. The first set to be analysed is the set of larger pieces. For each piece type of this set, and for each allowed orientation, we simulate the placement of a piece of that type in every point of the contours of the Inner-Fit Polygon (IFP) between the piece and the leather hide, in every points of contours of the IFP between the piece and the quality zones, and in every points of the NFP between the piece and the current layout. The IFP between two pieces represents the set of feasible points to place a piece inside another one.

For each simulated placement, we evaluate the corresponding fitness of the piece in the chosen point. The placement that maximizes the evaluation function determines the piece to be placed, its orientation and the placement point in the hide. This procedure is repeated until all pieces from the selected set are placed or until there are no pieces in the set that do not constitute a valid placement. When at least one of these stopping criteria is reached, the NFPs are updated and the procedure is repeated with the following set. When the algorithm analyses the set of smaller pieces, these pieces are sorted by decreasing value of their area, and the pieces are placed by this order on the hide in the best point. This fact enables a significant reduction of computing time.

In order to evaluate the fitness quality of a piece in a given point, we compute first the offset of the piece. In practice, this operation consists in adding a strip at the border of the original piece. To perform this operation, we compute the Minkowski sum between the original polygon and a square. The fitness quality of a piece at a given point is evaluated by computing the overlap between the offset of the piece and the exterior of the hide, between the offset of the piece and the current layout, and between the piece and the quality zones of the hide. The overlap between the offset of the piece and the exterior part of the hide is a good indicator on how a piece fits in the contour of the hide. However, the piece can be placed far away from the contour. For this reason, the evaluation function considers the overlap between the offset of the piece and the pieces already placed on the hide. The third element of our evaluation function contributes to the use, wherever possible, of a zone with a quality lower than the highest quality zone. Thus, it is possible to minimize the waste of the highest quality zone with pieces (or parts of pieces) of low quality.

Test instances

The test instances are based in the real production from the automotive industry. The vehicle model X used in the instances is composed by 23 pieces. In practice, pieces from different models are not placed with each other in the same hide during the cutting process. For this reason, for each hide, each instance only has pieces from the model X. We classify the usable area of the hide according to four quality zones (A, B, C and D). The highest quality zone is A and the lower one is D; B and C are medium quality zones, being B better than C. The hide used in the instances (figure 1) has two quality zones and an infeasible placement zone. Quality zones A and D are represented in black and blue, respectively. The zone that is represented in grey refers to a defective zone. In this zone is not possible to place pieces.

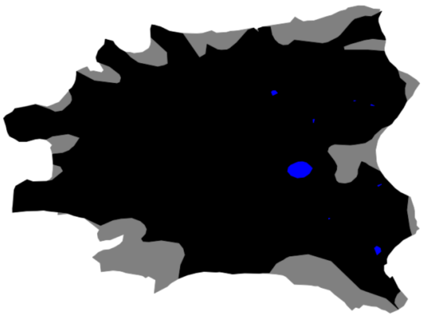

Fig. 1. Hide used in the computational tests.

For each instance, the offset parameters were changed. The level 1 is the level with the lowest offset parameter, while level 5 is the highest level offset. Levels 2, 3 and 4 have medium offset. The 23 pieces are divided in 10 sets, by increasing order of area, being the set 1 the set of smaller piece and the set 10 is the set of larger pieces. As a consequence, it may happen that sucessive sets do not have pieces.

The tests were performed in a PC with a 1.66 GHz processor and 1.99 GB of RAM. Table 1 defines the number of pieces for each type to be used in each test instance.

Analysis of computational results

The obtained results on the instances described above are presented in Table 2. From the tested instances, the instances 1, 11 and 12 present higher average utilization of the hides. The pieces that compose instance 11 belong to four different sets, including the set 1, which is the set of smaller pieces. In this instance, the use of the hide is higher for low offset levels. The processing time for the same instance is higher for the larger offsets. In contrast, in the instance 12, the usage of the hide usage is slightly larger compared to the usage that we get when larger offsets are used.

The good results are due to the combination of these types of pieces. The results of the three presented instances suggest a relation between the usage and the diversity of the placed pieces. In fact, if there are multiple types of irregular pieces, there are more alternatives. Another factor that yields larger usage is the diversity of the shapes and concavities of the pieces: the empty space in the layout can be filled by smaller pieces.

In instance 8, the used pieces are very small, and all of them are included in the hide. Processing times are the highest among all the instances. This reason is due to the fact that the feasible region is very large comparatively to the size of the pieces. An important issue is that for larger offsets, the layouts are more compact. This is due to the fact that when larger offsets are applied to small pieces, the overlap area can be very large and can include a large area of the current layout and the outer area of the hide. Therefore, the evaluation function would encourage this type of compactness.

The offset levels do not influence the hide usage. In instance 3, the usage is improved for larger offsets except for level 4. Low usage for these instances are due to the use of pieces of similar size without combination with smaller pieces which may help to fill the empty spaces.

	Instances												
Piece	1	2	3	4	5	6	7	8	9	10	11	12	**Set**
1	1						10		2		2		**2**
2	1				3						2		**4**
3	1		3							2			**6**
4	1				3				2		2		**4**
5	1		3						2	2			**6**
6	1			3					2		2		**5**
7	1				3						2		**4**
8	1	3								20		2	**10**
9	1							2			2	2	**1**
10	1							2			2	2	**1**
11	1							2			2	2	**1**
12	1							2			2	2	**1**
13	1							2			2	2	**1**
14	1							2			2	2	**1**
15	1			3							2	2	**5**
16	1					3			2		2		**3**
17	1					3					2		**3**
18	1							2	2		2	2	**1**
19	1			3							2		**5**
20	1					3					2		**3**
21	1	3							2	2		2	**10**
22	1		3							2			**6**
23	1		3							2			**6**

Table 1. Number (x10) of pieces of each type.

	Parameters	Level 1	Level 2	Level 3	Level 4	Level 5	Average
1	% Usage	74,6961	76,2569	765,039	76,6356	77,4918	76,2239
	time (sec)	2321,56	2197,36	1972,56	2120,64	2417,77	2205,98
2	% Usage	37,9945	37,9944	37,9944	37,9944	37,9944	37,9944
	time (sec)	1111,31	1057,94	999,859	1098,72	1178,92	1086,35
3	% Usage	42,5596	45,4911	51,5426	49,0517	52,318	48,1926
	time (sec)	5691,31	9180,08	7800,44	9696,8	11252,2	8724,17
4	% Usage	49,4655	48,021	48,4822	50,9643	50,9643	49,5795
	time (sec)	6227,81	11068,8	7852,77	8324,05	7709,59	8236,6
5	% Usage	58,2438	65,7623	59,4285	61,1211	65,7623	62,0636
	time (sec)	9979,75	15230,8	12407,2	13365,4	14224,7	13041,57
6	% Usage	60,1576	63,2329	64,0933	64,6067	68,564	64,1309
	time (sec)	11654,4	12313,8	12534,3	11634	13624,2	12352,14
7	% Usage	66,6506	69,8244	69,8244	65,6506	70,8823	68,5665
	time (sec)	5332,16	4752,76	5533,03	6325,16	6283,72	5645,37
8	% Usage	35,0486	35,0486	35,0486	35,0486	35,0486	35,0486
	time (sec)	27375,7	25927,8	19968,2	20677,4	22378,2	23265,46
9	% Usage	71,0796	69,5852	69,9621	69,9621	69,0077	69,9193
	time (sec)	871,063	912,922	851,266	941,985	955,547	906,56
10	% Usage	46,4661	49,3168	46,5064	52,1828	49,4127	48,777
	time (sec)	1545,95	1624,3	1571,02	1733,64	1801,06	1655,19
11	% Usage	77,7009	75,3903	74,1067	73,8431	73,1384	74,8359
	time (sec)	7726,75	8466,14	9003,38	10309,2	9320,99	8965,29
12	% Usage	74,4699	75,6739	75,712	75,9367	75,646	75,4877
	time (sec)	4933,81	5184,08	5267,55	5490,89	3189,5	4813,17

Table 2. Results of constructive heuristic.

LOCAL SEARCH IN THE NP WITH IRREGULAR SURFACES

Local search methods are improvement methods that differ from the constructive heuristics because they require for example a starting solution. Due to the performance and the potential quality of the generated solutions, local search methods have been applied to the NP by some authors. Despite the interest in these methods, meta-heuristics remain the most common solution methods used. As an example, we may cite the simulated annealing method [8, 9, 10] and tabu search [11].

The initial (or starting) solution contains information about what pieces are placed, their position in the hide, and the sequence by which these pieces are placed on the hide. The starting solution was obtained through a constructive heuristic similar to the one previously presented, but with some modifications in order to speed up its execution and favour its integration within a local search procedure. Thus, the new constructive procedure explores sequentially each set by decreasing area of its pieces. For each set (except the set of smaller pieces), we select the piece that has a larger IFP with the hide. It should be noted that each piece has as many IFPs as allowed orientations.

For each point of the IFP between the piece and the hide, we evaluate how well a piece fits in this region. To perform this test, we resort to an evaluation function that considers two components: the overlap between the offset of the piece with the exterior part of the hide, and the overlap between the offset of the piece and the current layout. The placement point which maximizes the evaluation function is chosen to place the piece.

The choice of the piece with the largest IFP is a way of anticipating a good fit. Since the placement of large pieces has a direct impact in the placement of the following ones, it is appropriate to explore all the possibilities in order to find the best possible fit. By doing so, we aim at limiting the generation of empty isolated spaces that may prevent the placement of the following pieces.

The process runs sequentially for each set. If there is no space to place the pieces from this set or if there are no pieces from this set to place, the process is repeated for the next set. When the process analyses the set of smaller pieces, the way the pieces are selected is distinct: the piece from this set that has the smaller IFP (with the hide) is selected to simulate the placement in every possible points of the IFP. This procedure reduces both the complexity and the computing time by exploring less points. Furthermore, this fact induces both a good fit because it attempts to select the smaller space among the irregular contours, and avoids final layouts with large empty spaces.

As mentioned before, it is necessary to know the sequence in which the pieces were placed in the initial solution. For the first piece of this sequence, we simulated its removal from the current layout. The empty space generated by this operation is used to apply the new constructive procedure, using pieces that have not been placed yet in the hide. This placement of these pieces will be evaluated and from this evaluation we can have two results: the new solution is better than the current solution, or there is no improvement of the current solution.

If the new solution is better, then it will become the current solution, from which new neighbor solutions will be generated, using the unplaced pieces. This means that the removed piece will be included in the set of unplaced pieces and, the pieces that were placed in application of the constructive heuristic process will compose the current solution.

If the new solution does not yield an improvement, the current solution is not updated, and the next neighborhood will be generated through the next piece removal (respecting the initial sequence on the constructive process) and then through the application of the constructive heuristic in the empty space generated by such a removal.

The process is repeated for each piece in the set of pieces that are sorted by placement order. It should be noted that since the pieces are placed by the constructive process, they start to belong to the set of placed pieces. Thus, they can be removed in a neighbor solution generated later. If this happens, it is also possible to add these pieces to other neighbor solutions generated later. The algorithm stops when all neighbor solutions were analysed, or when the maximum number of visited neighbor solutions is reached. In the latter case, the maximum number is a parameter of the algorithm.

Test Instances

The pieces used in the computational experiments correspond to the first 10 pieces of the model X presented above. Table 3 presents 18 test instances. For each instance, we give the demand for each piece (from 1 to 10), and the usage of the hide (percentage) for the constructive heuristic (column Const) and for the local search (column Local). The maximum number of visited neighbor solutions is 100. The tests were performed in a PC with a 1.66 GHz processor and 1.99 GB of RAM.

INST	1	2	3	4	5	6	7	8	9	10	*Const*	*Local*
1	2				2			2			59,42	60,47
2		2			2		2	2			52,64	53,35
3			2	2							44,87	53,84
4				2	2	2		2			54,26	57,56
5	2			2	2	2		2			60,6	62,12
6					2		2				55,62	57,75
7			2			2		2			49,4	52,52
8			4			4	4				48,79	52,66
9	10							4	40	40	77,47	78,04
10	4	4	4	4							57,34	60,62
11		4		4			4				52,59	57,13
12					4	4	4	4			54,05	54,64
13	4	4	4								57,34	59,67
14				4	4	4					56,53	57,45
15		4			4						53,6	58,39
16			2		2	2					49,26	51,08
17							4	4	80		75,45	- (*)
18			2		2						49,26	51,08

Table 3. Demand for each piece (x10) and results.

Analysis of the Computational Results

In the instances in which pieces from different sets were used, the usage of the hide increases in the local search method, comparatively to the constructive heuristic. Instance 3 presents the largest increase (8.97%), using pieces from two distinct sets. However, it is not possible to relate the good usage of the hides to the fact of using pieces from distinct sets. For example, both instances 1 and 2 present increases of 1%.

It is also possible to verify that if the initial solution has a good hide use, the improvements are less significant (instance 9) or even null (instance 17, marked with *). By the analysis of Table 3, it is noted that like in the presented heuristic constructive, the hide usage is higher in instances for which there exists more diversity in the shape of the pieces.

CONCLUSIONS

In this paper, a leather nesting problem was addressed. The orientation of the pieces is not fixed and the hide surface presents defects and quality zones. We proposed and analysed two original algorithms with promising results: a constructive algorithm and a local search method. The results for the construtive heuristic show that the layouts with more types of pieces have also a higher usage. The usage of the hides that have only large pieces is typically low. However, if small pieces are combined in these cases, the hide usage is improved. The results for the local search confirm the potentiality of the algorithm. They indicate improvements in 17 of 18 instances, compared to the construtive heuristic. For starting solutions with good values, the improvement of this method is less significant.

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SWARM INTELLIGENCE FOR SCHEDULING: A REVIEW

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Abstract: Swarm Intelligence generally refers to a problem-solving ability that emerges from the interaction of simple information-processing units. The concept of *Swarm* suggests multiplicity, distribution, stochasticity, randomness, and messiness. The concept of *Intelligence* suggests that problem-solving approach is successful considering learning, creativity, cognition capabilities. This paper introduces some of the theoretical foundations, the biological motivation and fundamental aspects of swarm intelligence based optimization techniques such Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO) and Artificial Bees Colony (ABC) algorithms for scheduling optimization.

Keywords: Decision support system(s), Meta-Heuristics, Scheduling tools for production management, Optimization techniques for manufacturing production.

INTRODUCTION

Evolutionary Computation (EC) techniques have been applied to the scheduling of orders in manufacturing systems, leading to a research area called Evolutionary Scheduling that is at the interface of Artificial Intelligence (AI) and Operational Research.

Scheduling problems are generally complex, large scale, constrained, and multi-objective in nature, and classical operational research techniques are often inadequate at solving them effectively. With the advent of computation intelligence, there is a renewed interest in solving scheduling problems through evolutionary computational techniques. Several EC techniques have been proposed. A summary of the most significant chronology milestones of evolutionary computation techniques is presented in table 1.

Evolutionary Computation is a growing research field of AI. EC is the general term for several computational techniques which use ideas and get inspiration from natural evolution/adaptation, such as natural selection and genetic inheritance. EC could be categorized in two main areas: the Evolutionary Algorithms (EA) and the Swarm Intelligence (SI).

An emerging area of research of Evolutionary Computation is the Swarm Intelligence (SI). SI is a new computational and behavioural paradigm for solving distributed problems based on self-organization. While its main principles are similar to those underlying the behaviour of natural systems consisting of many individuals, such as ant colonies and flocks of birds, SI is continuously incorporating new ideas, algorithms, and principles from the engineering and basic science communities.

Evolutionary Technique	Authors	Year	Refs.
Evolutionary programming	Fogel, Owens and Walsh	1966	[1]
Genetic Algorithms	Holland	1975	[2]
Scatter Search	Glover	1977	[3]
Artificial Immune Systems	Farmer, Packard and Perelson	1986	[4]
Swarm Intelligence	Beni and Wang	1989	[5]
Memetic Algorithms	Moscato	1989	[6]
Ant Colony Search Algorithm	Colorni, Dorigo and Maniezo	1992	[7]
Cultural Algorithms	Reynolds	1994	[8]
Particle swarm optimization	Kennedy and Eberhart	1995	[9]
Path Relinking	Glover	1996	[10]
Diferencial Evolution	Storn and Price	1996	[11]
Bees Algorithms	Pham, Ghanbarzadeh, Koc, Otri, Rahim and Zaidi	2005	[12]
Artificial Bee Colony	Karaboga and Akay	2005	[13]

Table 1 - Evolutionary Techniques Chronology

This paper aims at review some of the most recent contributions to the Evolutionary Scheduling research area.

The remaining sections of this paper are organized as follows: initially the theoretical foundations, the biological motivation and fundamental aspects of SI paradigm with focalization on the design and implementation of the Particle Swarm Optimization (PSO) Ant Colony Optimization (ACO) and Artificial Bees Colony (ABC) algorithms are summarized. Then, some recent applications of SI optimization methods to scheduling resolution are presented and, finally, the paper presents some conclusions.

SWARM INTELLIGENCE OPTIMIZATION METHODS

Swarm Intelligence is a relatively new approach to problem solving that takes inspiration from the collective intelligence of swarms of biological populations, and was discovered through simplified social behaviours model simulation of insects and of other animals **Erro! A origem da referência não foi encontrada.**. Among the most promising SI inspired optimization techniques are ACO, PSO and ABC optimization algorithms.

ANT COLONY OPTIMIZATION

Ant Colony Optimization (ACO) takes inspiration from the foraging behaviour of some ant species. These ants deposit pheromone on the ground in order to mark some favourable path that should be followed by other members of the colony. ACO exploits a similar mechanism for solving optimization problems.

The ACO algorithm is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. This algorithm, initially proposed by Marco Dorigo in his PhD thesis [7], is a member of ant colony algorithms family, in SI methods, and it constitutes some Meta-Heuristic optimizations.

Natural Ant Colony	*Artificial Ant Colony*
Ant	Agent
Ant Colony	Set of Ants/Iterations
Pheromone	Diversity Mechanism
Path	Solution
Evaporation	Pheromone update

Table 2 - Analogy between Natural and Artificial Ants

The first ACO algorithm is known as Ant System was aiming to search for an optimal path in a graph. It was based on the foraging behaviour of ants seeking a path between their colony and a source of food. The original idea has since diversified to solve a wider class of numerical problems, and as a result, several problems have emerged, drawing on several aspects of the behaviour of ants [15]. The general ACO algorithm is described in Algorithm 1 (Table 3). After initialization, the metaheuristic iterates over three phases: at each iteration, a number of solutions are constructed by the ants; these solutions could be then improved through a local search (this step is optional), and finally the pheromone is updated through evaporation and by increasing the pheromone levels associated with a chosen set of good solutions.

Algorithm 1: Ant Colony Optimization Metaheuristic

```
Set ACO parameters.
Initialize pheromone trails
While termination criteria not met do
     Construct AntSolutions
     Apply Localsearch (optional)
     Update Pheromones
EndWhile
```

Table 3 - Ant Colony Optimization Algorithm

Ant System is the first ACO algorithm proposed in the literature [7]. Its main characteristic is that, at each iteration, the pheromone values are updated by all the *m* ants that have built a solution in the iteration itself. The pheromone τ_{ij}, associated with the edge joining cities i and j, is updated as follows:

$$\tau_{ij} = (1 - \rho) * \tau_{ij} + \sum_{k=1}^{m} \Delta\tau_{ij}^{k} \quad (1)$$

where ρ is the evaporation rate, *m* is the number of ants, and τ_{kij} is the quantity of pheromone laid on edge (*i*, *j*) by ant *k*:

$$\Delta\tau_{ij}^{k} = \begin{cases} Q/L_k & \text{if ant k uses edge (i, j) in its tour} \\ 0 & \text{otherwise} \end{cases} \quad (2)$$

where *Q* is a constant, and L_k is the length of the tour constructed by ant *k*.

In the construction of a solution, ants select the following city to be visited through a stochastic mechanism. When ant *k* is in city *i* and has so far constructed the partial solution S^p, the probability of going to city *j* is given by:

$$p_{ij}^{k} = \begin{cases} \dfrac{\tau_{ij}^{\alpha} * \eta_{ij}^{\beta}}{\sum_{C_{ij} \in N(S^p)} \tau_{ij}^{\alpha} * \eta_{ij}^{\beta}} & \text{if } c_{ij} \in N(S^p) \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

where $N(s^p)$ is the set of feasible components; that is, edges (*i*, *j*) where *j* is a city not yet visited by the ant *k*. The parameters α and β control the relative importance of the pheromone versus the heuristic information η_{ij}, which is given by:

$$\eta_{ij} = \frac{1}{d_{ij}} \quad (4)$$

where d_{ij} is the distance between cities *i* and *j*.

Particle Swarm Optimization

Particle Swarm Optimization (PSO) is a population based stochastic optimization technique developed by Eberhart and Kennedy [9], inspired by social behaviour of bird flocking or fish schooling. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA).

Bird Flocking	Particle Swarm Optimization
Bird	Particle
Bird Flocking	Particle Swarm
Area overflown by birds	Search space
Bird localization during flight	Position
Bird localization where it found food or the nest	Optimal solution
Flight capabilities	Fitness
Best known position of bird	*pBest* (Individual Experience)
Best known position of oh whole population	*gBest* (Collective experience)

Table 4 - Analogy between Birds and PSO

The algorithm is initialized with a population of random solutions and searches for optimal solution by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. The detailed information will be given in following sections. Compared to GA, the advantages of PSO are that it is easier to implement and there are few parameters to adjust.

The particle swarm concept originated as a simulation of simplified social system. The original intent was to graphically simulate the choreography of a bird block or fish school. However, it was found that particle swarm model can be used as an optimizer.

Algorithm 2: Particle Swarm Optimization Metaheuristic

```
Initialize particles population in hyperspace
While termination criteria not met do
     Evaluate fitness of individual particles
     Modify velocities based on previous best
     and global best
EndWhile
```

Table 5 - Particle Swarm Optimization Algorithm

In PSO, instead of using genetic operators, as in the case of GAs, each particle (individual) adjusts its flying according with its own and group experiences. The general PSO algorithm is described in Algorithm 2 (Table 5).

Each particle is treated as a point in a D-dimensional space and is manipulated as described below in the original PSO algorithm:

$$v_{id} = v_{id}+c_1 * rand()(p_{id}-x_{id})+c_2\, rand()(p_{gd}-x_{id}) \quad (5)$$

$$x_{id} = x_{id} + v_{id} \quad (6)$$

where c_1 and c_2 are positive constants and *rand()* is a random function in the range [0,1], $X_i = (x_{i1}, x_{i2}, \ldots, x_{iD})$ represents the ith particle, $P_i = (p_{i1}, p_{i2}, \ldots, p_{iD})$ is the best previous position (position giving the best fitness value) of the particle, the symbol g represents the index of the best particle among all particles in the population, and $V_i = (v_{i1}, v_{i2}, \ldots, v_{iD})$ is the rate of the position change (velocity) for particle i.

Equation (5) describes how the velocity is dynamically updated and equation (6) the position update of the "flying" particles. Equation (5) is divided in three components, namely the momentum, the cognitive and the social component. In the first component, the velocity cannot be changed abruptly: it is adjusted based on the current velocity. The second component represents the learning from its own flying experience. The third component consists on the group learning flying experience [9].

Most applications of optimization algorithms are tailored to static problems. Many real-world systems, however, change its state frequently. These system state changes result in a requirement for frequent, sometimes almost continuous, re-optimization. It has been demonstrated that PSO can be successfully applied to tracking and optimizing dynamic systems [16].

The first parameter added into the original PSO algorithm is the inertia weight ω. The dynamic equation of PSO with inertia weight is modified to be:

$$v_{id} = \cdot\, v_{id}+c_1\, rand()(p_{id}-x_{id})+c_2\, rand()(p_{gd}-x_{id}) \quad (7)$$

$$x_{id} = x_{id} + v_{id} \quad (8)$$

where ω constitutes the inertia weight that introduces a balance between the global and the local search abilities. A large inertia facilitates a global search while a small inertia weight facilitates the local search.

Bees Based Algorithms

The Bees Algorithm is a new population-based search algorithm, first developed in 2005 by Pham et al. [12] and Karaboga et al. [13] independently. The algorithm mimics the food foraging behaviour of swarms of honey bees. In its basic version, the algorithm performs a kind of neighbourhood search combined with random search and can be used for optimization problems.

In 2005, Pham proposed a *Bees Algorithm* in a technical report [12] inspired in the foraging behaviour of honey bees to find food sources, has an optimization algorithm to find a optimal solution.

At the same time Karaboga [13] proposes a very similar Artificial Bee Colony (ABC) algorithm that proposes a similar inspiration in the foraging behaviour of the bees.

Natural Bee Colony	Artificial Bee Colony
Food Source	Solution
Quality of nectar	Objective Function
Onlookers	Exploitation of search
Scout	Exploration of search

Table 6 - Analogy between Natural and Artificial Bees

Real bees are social insects living in organized group called hive. In a beehive, the individuals have some specific tasks performed by specialized individuals. The goal of this organization is to maximize the amount of nectar in the colony getting the utmost of the food sources. The bases of the model of ABC are three types of specialized bees Employed, Onlooker and Scout that represent a minimal model of the real swarm intelligent forage selection.

Employed bees are in the same number of food sources (solutions) and are responsible to explore one and only one food source at the time and give information to other bees. When an employed bee left is food source becomes a scout bee. Onlooker bees turret in the hive for a information of a employed bees to establish a good food source. Scouts bees seek environment trying to find a new food source depending on an internal motivation or external clues or randomly. Half of the hive is composed by employed bees and the other half by onlooker bees. The food source position represents a solution that is measured by the nectar amount correspond to the quality of the solution.

Algorithm 3: ABC Algorithm

```
Initialization of Bee Population
Population
Cycle = 1
While cycle <> Maximum Cycle Number
   Employed Bees Phase
   Calculate Probabilities for Onlookers
   Onlooker Bees Phase
   Scout Bees Phase
   Memorize the best solution achieved so far
EndWhile
```

Table 7 - ABC Algorithm

Initialization of bee population

In the initialization phase the algorithm generates randomly an initial distributed solutions, with $\frac{sn}{2}$ solutions were sn is the size of the population, which will be the food field for the employed bees. Each x_i (i=1,2,…, $\frac{sn}{2}$) it's a dimensional vector D. The ABC algorithm does not assure that all initial solution is realizable to increase the performance of the algorithm. These types of solution will disappear by the normal acting of the algorithm. Values between the limits of the parameterization are assigned to the solution and a $failure_i$ value is addicted to analyze when this solution i must be abandoned.

After the ABC validates the population do a repeated cycles of searches of employed, onlooker and scout bees.

Employed bee phase

An employed bee performs an alteration in their position of food source based in an equation and evaluates the nectar amount in the new position.

$$v_{ij} = \begin{cases} x_{ij} + \emptyset(x_{ij} - x_{kj}), \ if \ R_j < MR \\ x_{ij}, \ otherwise \end{cases} \quad (9)$$

where $k \in \{1,2,\dots,sn\}$ is randomly chosen index that has to be different from i and $\emptyset_{ij}$ is uniformly distributed random real number in the range of [−1,1]. Rj is uniformly distributed random real number in the range of [0,1] and MR is a control parameter of ABC algorithm in the range of [0,1] which controls the number of parameters to be modified.

Fig. 1 - Equation for new solution Erro! A origem da referência não foi encontrada.

After a new solution the algorithm select the solution by the follow rules:

- Two realizable solutions – select the one with the best amount of nectar (fitness) value;
- One solution realizable and one unrealizable – select the realizable;
- Two unrealizable solution - select the one with the smaller degradation factor;

Finished the search the employed bee share the information with the onlooker bees and the solutions are select based in a probabilistic selection by the value of fitness or violation of the solutions depending if they are realizable or unrealizable.

Onlooker bee phase

The onlooker bee select is own food source based in a probabilistic rate according to the nectar solution amount. That uses the same equation (9) to create a new food source validate and adjusting the new solution according to the parameterization.

Scout bee phase

After all above process all food sources that not must be explored anymore are abandoned.

The employed bees that left the food source get a new position from scouts search.

SWARM INTELLIGENCE FOR SCHEDULING

Scheduling is a decision-making process that is used on a regular basis in many manufacturing and services industries. It deals with the allocation of resources to tasks over given time periods and its goal could be the optimization of one or more optimization objectives. In current and global competitive environments effective sequencing and scheduling has become imperative for survival in the market-place. Scheduling appears in diverse areas of science, engineering and industry and takes different forms depending on the restrictions and optimization criteria of the operational environments.

Work/Technique	Authors	Year	Refs
Book "Work, Wages, and Profits"	Gantt	1916	[17]
Various Optimizers for Single Stage Production	Smith, Johnson and Jackson	1956	[18]
Scheduling presentation to AI community	Fox	1982	[19]
Genetic algorithms	Davis,	1985	[20]
	Yamada and Nakano	1991	[21]
Shifting bottleneck	Adams, Balas and Zawack	1988	[22]
Simulated Annealing	Matsuo, Suh and Sullivan	1988	[23]
Tabu Search	Barnes, Laguna and Glover	1992	[24]
Ant Colony Optimization	Van der Zwaan and Marques	1999	[25]
Particle Swarm Optimization	Jerald, Asolcan, Prabaharan, et al.	2004	[26]
	Cagnina, Esquivel and Gallard		[27]
Bee based Algrithms	Chong, Low, Sivakumar and Gay	2006	[28]
	Pan, Tasgetiren, Suganthan and Chua	2010	[29]

Table 8 - A non exhaustive genealogy of scheduling contributions

References to scheduling contributions in manufacturing could be situated at the beginning of 20th century with the work of Henry Gantt and other pioneers. In 1916, in his book "Work, Wages, and Profits" [17], Henry Gantt explicitly discusses scheduling, especially in the Job-shop environment.

Some of the first scheduling publications appear in the industrial engineering and operations research literature associated to Naval Research Logistics Quarterly in the early fifties and contained results by W.E. Smith, S.M. Johnson and J.R. Jackson [18]. The scheduling problem was introduced with some impact to the community of Artificial Intelligence in 1982 by Mark S. Fox, through the paper titled "Job-Shop Scheduling: An Investigation in Constraint-Directed Reasoning" [19].

Since then several proposals through Exact Methods and AI based optimization, generally referred as Meta-heuristics or Nature Inspired Techniques, have been referred in literature. A non exhaustive genealogy of the most significant contributions to scheduling resolutions is presented in table 8.

Swarm Intelligence-based techniques have been applied to a wide range of combinatorial optimization and search problems in which the task is to accommodate a set of entities such as events, activities, resources and people into a time-space so that the available resources are utilized as efficiently as possible and the additional constraints are satisfied. Examples of scheduling problems are production scheduling, personnel scheduling, transport scheduling, scheduling for the web, project scheduling, etc.

In this work we concentrate our review to the scheduling resolution in manufacturing systems.

Ant Colony Optimization

Ant Colony optimization is probably the most successful example of artificial/engineering swarm intelligence system with numerous applications to real-world problems. ACO is one of the most successful techniques in the wider field of swarm intelligence. The significant research efforts on ACO have established it as a mature metaheuristic that can lead to very effective algorithms for many difficult optimization problems.

Van der Zwaan and Marques [25] developed an improved Ant System for the Job-Shop scheduling problem and study the difference that parameterization makes in an ACO. Huang and Liao [30] propose hybridization between ACO and Tabu Search in a Job Shop problem using a specific pheromone trail definition inspired from Shifting Bottleneck method. Recently, Sun, Wang and Fang [31] present an approach based on ACO optimization to a discrete Job-Shop Scheduling.

Merkle and Middendorf [32] describe a contribution for solving permutation problems to Single Machine Problems for Total Weighted minimization. Blum [33] proposes an implementation of ACO in an Open Shop problem using a hybrid approach combining ACO with Bean Search.

Liao and Juan [34] propose an ACO to minimize the tardiness in a Single Machine

Problems with utilization of setup times. In Yagmahan and Yenisey [35] a multi-objective scheduling problem approach based on ACO for scheduling to reduce the total scheduling cost is proposed.

Madureira and Pereira [36] proposed a novel approach for the resolution of Dynamic Scheduling Problem by combining different techniques, like Autonomic Computing (AC), Multi-Agent Systems (MAS), Case-based Reasoning (CBR), and Bio-Inspired Optimization Techniques (mainly Ant Colony Optimization).

Particle Swarm Optimization

PSO has been applied to different problems and is another example of successful artificial/engineering swarm intelligence paradigm. Within little more than a decade hundreds of papers have been reported successful applications of PSO to scheduling. An extensive survey of PSO applications is made by Poli [37].

The application to scheduling problems reports to Tasgetiren et al. [38] work presenting an application of PSO to Single Machine Problem for Total Weighted Tardiness optimization. Sha and Hsu [39] presents a hybrid PSO technique adjusting the features of some parameters to a better utilization of PSO in Job Shop scheduling problem and applying Tabu Search to depurate the final solution. More recently in [40] same authors present a work using PSO in an Open Shop scheduling problem where they propose a "new" PSO method with some improvements in particle comportment. In Liao, Tseng and Luarnb [41] a utilization of PSO in a Flow-Shop scheduling problem using an application of PSO with Local Search is described. The authors performed a test suite comparing PSO with some Genetic Algorithms techniques. Ercan [42] explores in his work the implementation of PSO, Hybrid PSO and other optimization techniques for a hybrid Flow-Shop scheduling problem.

In 2010, Chen et al. [43] proposes an improved PSO approach to solve the resource-constrained scheduling problem. Low Hsu and Su [44] present a work with the application of PSO in a Single-Machine Scheduling Problem with periodic maintenance. The authors adjust the original algorithm to a most efficient application considering features of a Single Machine Problem. Lin et al. [45] proposes an "efficient" Job-Shop algorithm based in PSO. The authors refer a MPSO algorithm that is a combination of PSO, multi-type individual enhancement scheme and random-key encoding scheme.

Madureira et al. [46] proposed a hybrid approach for Dynamic Manufacturing Scheduling Optimization through Collective Intelligence and Swarm Intelligence. The proposed system is applied to the problem of jobs scheduling on dynamic manufacturing environments.

Bees Based Algorithms

The Bee based algorithms are the most recent SI optimization methods under study in this work. A few scheduling applications to this algorithm have been referred on literature.

Chong et al. [28] propose an application of Bee Colony Optimization (BCO) to a Job-Shop Scheduling making a comparison of BCO with ACO and Tabu Search. In this work the Tabu search results are clearly more effective than the others in study. Wong and Chong [47] propose in 2008 an improvement to BCO with Big Valley landscape exploitation. The results were compared with Shifting Bottleneck Heuristic, Tabu Search Algorithm and Bee Colony Algorithm with Neighbourhood Search on Taillard JSSP benchmark [48]. Results show that it is comparable to these approaches.

Pan et al. [29] proposes an ABC for a Flow - Shop scheduling problem presenting an improvement of the original ABC. In this work were considered different source of food not as a solution but as discrete job permutation and different neighbouring generation. Huang and Lin [49] presents an Open-Shop scheduling problem work "with an idle-time-based filtering scheme", a system that can automatically adapt their behaviour stopping the search in solutions with insufficient fitness, decreasing "time–cost for the remaining partial solution time-cost".

CONCLUSIONS AND FURTHER WORK

Evolutionary Computation techniques have been applied to the scheduling of orders in manufacturing systems, leading to a research area called Evolutionary Scheduling that is at the interface of Artificial Intelligence and Operational Research.

Theoretical foundations of swarm intelligence paradigm with main focus on the implementation and illustration of ACO, PSO and ABC optimization algorithms have been discussed in detail, followed by an overview of optimization techniques highlighting the first main applications of Nature Inspired Optimization techniques for scheduling resolution. Finally, some of the most current and noteworthy applications of Swarm Intelligence based algorithms for scheduling resolution in manufacturing systems are surveyed.

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ASSEMBLY LINE BALANCING USING GENETIC ALGORITHMS

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Abstract: When defining the layout for flow or production lines, it is necessary to select the best combination of operations to be performed at each work station. This process requires the fulfillment of a set of conditions. It is necessary to guarantee that the operations are performed according to a feasible sequence and that approximately equal quantities of time are used in each workstation. This process is called Assembly Line Balancing. The Assembly Line Balancing problems are complex to solve, mainly due to the high number of possible combinations. Among the methods used for this purpose, there are trial and error methods, heuristics methods, computational methods for the evaluation of different options until a good solution is found and optimization methods. In this paper is presented an application that was developed to solve Assembly Line Balancing problems using a Genetic Algorithm. This application, including an interface with the user, was developed in the C# programming language.

Keywords: Assembly Line Balancing, Genetic Algorithms.

INTRODUCTION

An assembly line consists in multiple workstations in sequence, each with a set of associated tasks, devoted to the manufacture or assembly of goods or products. Each task under consideration has a set of precedence relations with other tasks, specifying that some of them must be completed before the task can start. Each task has also associated an execution time. The execution time of each workstation must fulfill the Takt Time (TT), in order for the line to have a steady flow while achieving the demand, which is called Assembly Line Balancing Problem (ALBP).

There are two types of Simple Assembly Line Balancing Problems (SALBP):

- SALBP-1: Given the Takt time, minimize the number of workstations.
- SALBP-2: Given the number of workstations, minimize the cycle time.

The SALBP-1 is mainly present when a new assembly line system has to be installed and the external demand can be estimated. By opposition, SALBP-2 leads to the maximization of the production of an already existing assembly line. This is of importance if any changes take place on the production process or on the demand structure [1].

Among the methods used with this purpose, are trial and error methods, heuristics methods [2], computational methods for evaluation different options until a good solution is found and optimization methods [3].

In this work is described an application that was developed to solve Assembly Line Balancing problems using a Genetic Algorithm (GA). This application includes a user interface for the easy definition of the problem and for the presentation of the results to the user. The application was developed in the C# programming language.

Bearing these ideas in mind, the remaining of this paper is organized as follows. Section two describes the assembly line balancing problem. Section three presents a brief description of GAs. Based on this theoretical foundation, section four introduces the developed Genetic Algorithm for the application under consideration and section five presents the results achieved by this application when used to solve an ALBP. Finally, in section six are presented the main conclusion of this work and are proposed some ideas for future developments of the developed GA and application.

DEFINING THE ASSEMBLY LINE BALANCING PROBLEM

In order to clearly describe the problem of ALB, an example problem is described in the following. Consider the process diagram (precedence diagram) for the production / assembly of an example product, given in **Erro! A origem da referência não foi encontrada.**.

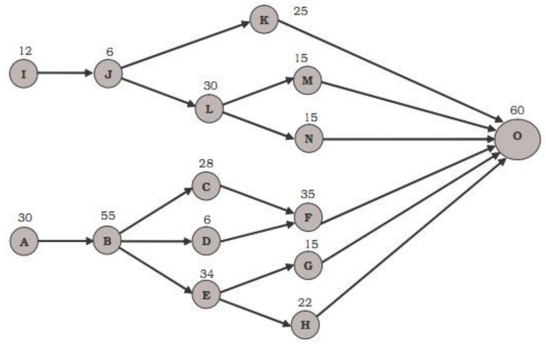

Fig. 1. Ordered graph of tasks

In this case, the production / assembly of the product that we are considering requires N tasks (in this case, N = 15) and the time necessary to complete each task (the value depicted above the corresponding operation) is t(i) (in the problem described by Fig. 1, 1 ≤ i ≤ 15).

The question of ALB is:

- (i) SALBP-1: given the Takt time, how to assign the N tasks to M stations (where, generally, M ≤ N), in order to minimize the number of workstations?
- (ii) SALBP-2: given the number of workstations (M), how to assign the N tasks to M stations, in order to minimize the cycle time?

Definitions and Concepts

Considering that a production / assembly operation is composed of N tasks, and that the time necessary to complete operation i (i = 1, 2, …, N) is t(i), then the time needed to finish a complete unit is given by equation (1):

$$\sum_{i=1}^{k} t_i \quad (1)$$

The Takt time (TT) of an assembly line is given by equation (2):

$$TT = \frac{time\ avaiable\ per\ period}{number\ of\ units\ wanted\ per\ period} \quad (2)$$

In order to guarantee that the line, after being balanced, is able to produce goods / products according to the requested demand, the cycle time of an assembly line must be equal or lower than the Takt time. The cycle time can be defined as:

- 1. the time between the output, at the end of the line, of each successive units;
- 2. the maximum time necessary in each one of the line workstations.

Considering the previous expressions, the minimal number of workstations necessary for the assembly line, to guarantee the fulfilment of the Takt Time is given by equation (3):

$$n_{min} = \frac{\sum_{i=1}^{k} t_i}{TT} \quad (3)$$

After the line balancing has been completed, it is possible to compute its efficiency. One possible expression to calculate the efficiency of the obtained solution is given by equation (4):

$$e = \frac{\sum_{i=1}^{k} t_i}{n \times TT} - n \times TT \quad (4)$$

GENETIC ALGORITHMS

Genetic Algorithms (GA) were developed by John H. Holland, his colleges and students in the 1960’s. The purposes of Holland’s research were two:

- (i) to abstract and rigorously explain the adaptive processes of natural systems, and
- (ii) design artificial systems software that retains the important mechanisms of natural system.

This approach led to important discoveries in both natural systems and in artificial systems [2, 3].

Genetic algorithms are a family of computational models inspired by genetics and natural evolution. These algorithms model a solution to a specific problem in a data structure, called a chromosome, and apply operators that recombine these structures while preserving critical information [4, 5].

Briefly, the outline of a GA is as follows:

- **Start**: Generate a random population of n suitable solutions (chromosomes). The values for the genes that constitute the chromosome are randomly distributed according to the corresponding parameters.
- **Fitness**: Select and evaluate the fitness function for each chromosome.
- **New population**: Create a new population by repeating the following steps:
  - **Selection** - Select the best parent chromosomes according to their fitness. These solutions are copied without changes to the new population (elitism).
  - **Crossover -** Select 60% to 90% of the individuals to be replaced by the crossover of the parents: two random

parents are chosen and an arithmetic mean operation is performed to produce one new offspring.

- **Mutation -** Select 0.1% to 5% of the individuals to be replaced by mutation of the parents: one random parent is chosen.

- **Spontaneous generation** - The remaining individuals are replaced by new randomly generated ones (such as in step 1).

- **Loop** - If the stop criteria were achieved then the algorithm stops, else, go to step 2.

GENETIC ALGORITHM DEVELOPMENT

In this section is described and explained the developed GA.

The developed Genetic Algorithm works with a fixed population size of 20 individuals and the initial population is randomly generated.

Coding problem

To simplify the coding of the problem, a number is assigned to each task. For example, to task "A" it is assigned number "1", to task "B", number "2", and so forth, until all tasks have a number assigned. This way the problem is codified using Permutation encoding. Each gene in the chromosome represents a task. The order of the genes in the chromosome sets the order in which the tasks are executed.

In Fig. 2 is shown an example of a chromosome coded. It is possible to verify from this example that every number represents a task.

2	1	8	3	4	6	7	5	10	9

Fig. 2. Chromosome and the corresponding genes

Selection

The selection method is "Selection by tournament". According to this selection method three chromosomes are randomly selected from the population. From these chromosomes, the one with the highest fitness is selected to be used in the subsequent crossover and mutation operations.

Crossover and Mutation

In this GA, the crossover operation is not applied to the chromosomes. In this particular case, this operation would compromise the integrity of the solutions, since it would make the same gene repeated in a chromosome (unless both chromosomes were exactly equal). Therefore, it is only applied the mutation operator to generate a new chromosome.

The mutation operator is tested with three options. In the first option two random positions are selected, and the corresponding genes are exchanged. For the second option only one position is randomly selected and the corresponding gene is switched with the consecutive one. After several tests, the results that revealed better performance are the tests applying the third mutation operator option. This third option is described below and is the one that was implemented.

The mutation operator works according to the following: two random positions are selected in the chromosome; the first selected position is the position of the gene that will be moved, the second is the new position of the gene. The genes between the first and second positions, including the gene on the second position will be shifted one position to the right, or left, according to the selected positions, as presented in the example depicted in Fig. 3.

Initial Chromosome	7	5	1	4	2	9	10	3	8	6
Final chromosome	7	5	1	2	9	10	3	4	8	6

Fig. 3. Example of a Mutation

To improve the algorithm, the mutations are done dynamically. This is performed by counting the number of operations in the problem, and the total number of precedents (the sum of the number of precedence's of all tasks). The number of mutations done in each new generation is set according with this total (corresponds to one quarter of this total).

Design of the fitness function

Crossover and mutation may create some infeasible solutions when the GA is used to solve ALBP. In these cases, individuals that infringe one or more precedence restrictions might appear in the population. To prevent these situations, a penalty function is created to force the individuals of each generation to evolve to feasible solutions.

So it is created a variable (called "penalty") to count the penalties in the new generated chromosome. This variable is incremented each time that a precedence restriction is not satisfied, and also when the number of workstations is superior to the desired one. In this case the increment of the variable is equal to the number of workstations above the desire value.

At the beginning of the algorithm the number of precedence's existing in the problem to be solved is counted. This value is used to know the maximum number of possible penalties. Based on this value, the fitness of the chromosome is calculated, and this value is kept in the variable, "max_penalty".

The fitness function is given by expression (5).

$$Fitness = \frac{Max_{penalty} - penalty}{Max_{penalty}} \times 100 \qquad (5)$$

GA stop criteria

Being the objective of the GA to obtain a solution that meets the precedence criteria and satisfies the desired number of workstations, the solution is obtained when there is a chromosome with a value of the fitness function equal to 100%.

Based on the previous idea, the stop criteria chosen in this GA were the fitness value. Therefore, when the GA finds a solution with a 100% fitness, the algorithms stops.

Flow diagram of the developed GA

Figure 4 presents a flow diagram of the developed GA. Looking at this diagram it is possible to see how the algorithm works. This GA runs until it obtains the number of solutions defined by the user. This way, if it is defined that the software has to find three solutions, this GA will automatically run for three times.

Improvement of the GA

To improve the results obtained by the first GA (whose algorithm was just described), a second version was implemented. This second GA only works on the solutions obtained by the first one, which we may call "feasible" solutions. Consequently, the population of this GA is very small, and limited to the solutions found by the first one.

This second GA will randomly select one of the obtained solutions chromosome, and apply a mutation to it. The new solution is then submitted to an evaluation, based on a new fitness function, being calculated the idleness of the corresponding solution and the standard deviation of the idleness of each workstation. Based on those values, it is verified if the solution is better than the original one; in case it is, then this solution chromosome replaces the original chromosome.

This second GA will run for 500,000 iterations.

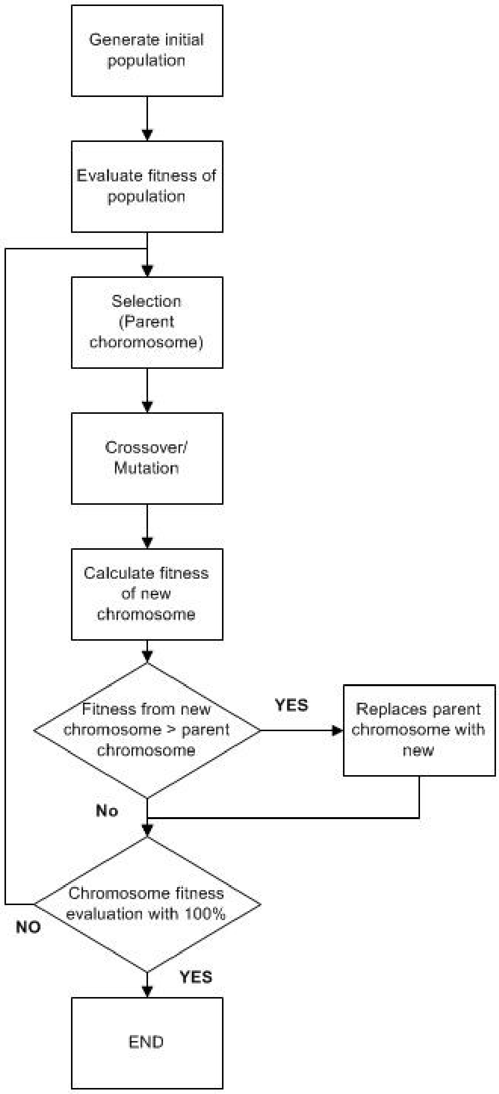

Fig. 4. Flow diagram of the GA

SIMULATION RESULTS

To test the developed application, the GA was applied to an example problem, in order to be possible to compare the results of the obtained solution using this application, and the solutions obtained by other authors, using distinct approaches.

The problem in question is an assembly line for a washing machine water pump, for which there is an estimated demand of 200 units per day. The assembly line is considered to work 480 minutes a day [6].

Table 1 presents the necessary operations to assemble the washing machine water pumps, including the times needed for each operation and the required precedence relations.

To solve this problem, the data presented in Table 1 was inserted in the developed software application, and the algorithm was run. Figure 5 presents the developed graphical interface for the input of the parameters.

In the left upper part of this figure it is possible to see a table where the data corresponding to the assembly line is introduced. Following, it is introduced the uptime of the line and the number of units that are desired to produce in that time.

When the application begins to compute the solution, the algorithm starts by generating the initial population and calculates the fitness of each chromosome, according to the first two blocks presented in the flow diagram depicted in Figure 4.

After that, the genetic algorithm enters a loop (also depicted in the flow diagram of Figure 4) to find the number of solutions to the problem defined by the user (in the case of this example, the number of solutions is three, as can be seen on the top right corner of Figure 5).

Operations	Time(seconds)	Precedents
A	30	-
B	55	A
C	28	B
D	6	B
E	34	B
F	35	C,D
G	15	E
H	22	E
I	12	-
J	6	I
K	25	J
L	30	J
M	15	L
N	15	L
O	60	K,M,N,F,G,H
Tempo Total	388 (s) ≈ 6,47 (min)	

Table 1. Operations, time duration and precedence's for the assembly of washing machines water pumps

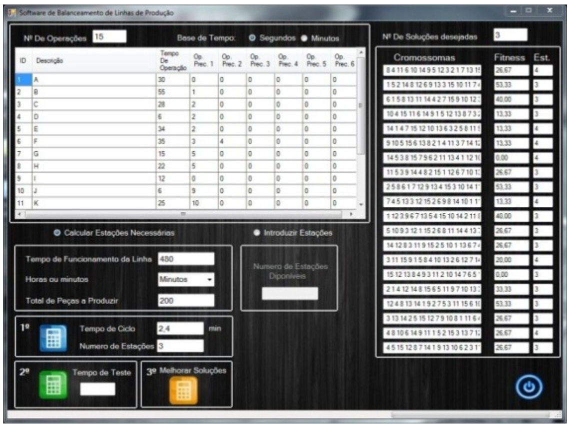

Fig. 5. Graphical interface

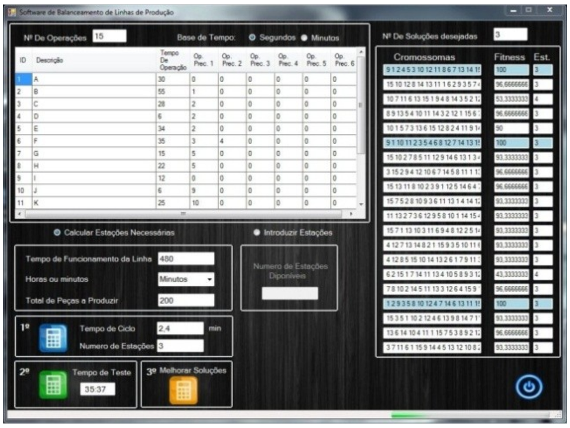

Fig. 6. Balancing line solutions

In the particular case of the problem under consideration, the algorithm runs for 35 minutes and 37 seconds to find the three solutions. The solutions are showed in Figure 6, being the corresponding chromosomes highlighted in blue.

After the first GA finds the "feasible" solutions, the second GA is executed to improve these results. In this example the software is able to obtain two better solutions, being only presented one of them in Figure 7.

The application also presents for the proposed solution, its efficiency, the delay of the balancing and total line idle time, the idleness and the standard deviation of the idleness of each workstation, as can be seen also in Figure 7.

In the solution window, presented in Figure 7 it is also depicted a graphic, which represents the busy time in each workstation (blue part of the bar) and the idleness (green part of the bar).

ANALYSYS OF THE RESULTS

In the sequel are compared the solutions obtained with the GA, and the solutions obtained through the use of heuristics to solve this same problem.

Fig. 7. Optimum result for the problem

Workstation	1	2	3
GA Solution	9 1 2 5	3 10 4 11 12 6	7 13 8 14 15
	I A B E	C J D K L F	G M H N O
	131	130	127
	13	14	17
Idleness	1,27%		
Heuristics Solution	1 9 2 10 11	12 3 4 13 14 6	5 7 8 15
	A I B J K	L C D M N F	E G H O
	128	129	131
	16	15	13
Idleness	1,27%		

Table 2. Comparison of the results obtained through the GA with the ones obtained using heuristics.

To better compare the results, it is calculated the idleness of the solution obtained using heuristics and this value is compared with the results obtained using the GA. The idleness is the percentage of inactivity in the assembly line. It can be obtained using the following expression.

$$\%\ \text{idleness} = \frac{\sum \text{idleness of each workstation}}{number\ os\ workstations \times TT} \quad (6)$$

Table 2 compares the balancing of the line when both methods are used. This table presents, for each workstation, the tasks, the total time, the idleness, and the idleness of the full assembly line.

As shown in the previous table, the solution obtained using the GA has an idleness equal of the solution obtained through the application of heuristics. That means that the solution presented by the GA is a valid solution to this problem.

Although both solutions present the same idleness, analysing the table it is possible to realize that the solutions presented by both methods are different.

CONCLUSIONS

When defining the layout for flow or production lines, it is necessary to perform the Line Balancing. In this paper was presented an application that was developed to solve Assembly Line Balancing problems using a Genetic Algorithm. This application, developed in the C# programming language, includes a user interface.

To test the GA, the developed application was applied to an example problem, in order to make possible a comparison of the obtained results with those obtained using heuristic methods.

It was verified that the solution found with the GA presents an efficiency and an idle time for the line equal to the solution obtained by the application of heuristic methods, while taking 35 minutes of run time. Furthermore, it should be mentioned that the GA found more than one feasible solution to the problem.

Given the results obtained with this application, the authors intend to improve the GA in order to allow the user to dynamically adjust the cycle time or the number of workstations to improve the results for more complex problems.

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AN ONTOLOGY FOR PRODUCTION SYSTEMS ENVIRONMENTS OF SCHEDULING PROBLEMS

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Abstract: The scheduling function in a manufacturing company seeks to schedule production activities towards on one hand optimizing of the use of available production resources and on the other to effectively achieve organization objectives, including the delivery of customer orders on time. This function can be performed using methods that were and are still being developed by a large community of academicians and practitioners concerned with good operation of manufacturing systems. The large variety of situations requires that a precise characterization and easy description and identification of the scheduling problems are made in order to choose and access the adequate method among the large number and variety available. Nowadays this choice and availability is possible through the Internet. Attempts have been made in the past to create ontologies and notations for easily describing and codifying scheduling problems. However, none of the known ontologies and notations is comprehensive enough to describe and characterize all the scheduling problems that may appear in industry and in research, neither lend themselves to easy use for search and access of scheduling methods through the Internet. One important field of scheduling problems characterization is the production systems environment. This paper gives a contribution towards a unified and comprehensive ontology for scheduling problems, oriented for searching and accessing methods through the Internet, focusing, at this stage, on the production systems environment

Keywords: Scheduling, Production Systems, Ontology

INTRODUCTION

The scheduling function in a manufacturing company seeks to schedule production activities towards on one hand optimizing of the use of available production resources and on the other to effectively achieve organization objectives, namely the delivery of customer orders on time.

This work presents and describes an ontology for characterization of production systems environments in the context of scheduling problems that appear in manufacturing. The aim is to contribute for better understanding of the problems, easing their resolution processes and facilitate the access to procedures, methods and algorithms that are available over the internet. This is in fact one of the important motivations behind the development of the ontology here presented [1, 2, 3, 4].

Although quite a few ontologies for scheduling problems had been put forward in the past [5, 6, 7, 8, 9], none seems to be comprehensive enough neither thought to be used for Internet collaboration to scheduling problem solving. This paper gives a contribution in these directions by starting with a proposal of an ontology for the conceptualization and description of production systems environments related to the scheduling problems which occur in industry or may be addressed in academic and research context.

An ontology defines a set of representational primitives with which to model a domain of knowledge [10]. A few general approaches to manufacturing related ontologies have already been developed by several authors [10, 11, 12]. A more specific one, related to task oriented scheduling and mainly oriented to problem solving, has been reported by Rajpathak [13].

We use a field class α to characterise several production systems required in the theory and practice of scheduling problem solving. We borrow this representation from the three field notation $\alpha|\beta|\gamma$ presented by Graham et al [6]. In this notation α specifies production environments, β the jobs and production resources' characteristics and constraints and γ the optimization criteria of the scheduling problems. In this paper we extend the range of production environments beyond what has been identified by Graham et al [6] and include ideas from other ontologies, in particular from that referred by Brucker [7] .

The paper is organized as follows. First a brief description of production scheduling is presented. Then the proposed ontology is described in terms of important attributes for characterization and description of production systems environments of scheduling problems. In parallel, a notation for codified description of the environments is given. Next some examples of production environments are described using the notation. Finally some concluding remarks are presented.

PRODUCTION SCHEDULING

Production scheduling may be defined as the activity of allocating production means or resources to operations of jobs, sequencing them and ensuring their effective and efficient processing within a certain time period. The result of this is usually expressed in a production schedule. A good schedule enables a company to make good use of the available resources and effective achievement of operational objectives. Thus the process of scheduling problem solving is essentially concerned with finding an optimal or good sequence for jobs' execution on the available workstations of a production system. Frequently the start and finishing times of every job operation on each workstation is required. This information completely defines the schedule for the necessary jobs to be processed.

PROPOSED ONTOLOGY

Scheduling problems have a set of characteristics that need specification. Some are necessary for characterizing the production environment where scheduling occurs. This depends both on production system and jobs' characteristics.

The ontology here proposed for of production systems environments is part of a more comprehensive one, under development by the authors, also based on a "$\alpha|\beta|\gamma$" notation, and exploring two strategies, namely aggregation and extension of existing ontologies. Thus initially an aggregation and reorganization of parameters used by other ontologies was attempted and due adjustments made; then the extension of the classification and description of production environments of scheduling problems was performed. As a result an extended and more comprehensive and unifying ontology is being constructed.

The paper focuses on the characterization and classification of the production systems environments of scheduling problems represented by the class α of parameters.

PRODUCTION SYSTEMS ENVIRONMENTS

The classes of production systems environments for production scheduling dependent simultaneously on jobs' processing requirements and on the available number and processing capabilities of machines as a function of processing requirements of jobs. This determines the number of stages of processing required in a system, jobs' flow pattern, workstation formation and functional workstation grouping. These are the fundamental aspects that will be used to define and describe the production systems environments that we find in the theory and practice of scheduling. Processors, here also referred as machines, are the fundamental components of workstations where processing stages or operations of jobs take place. A workstation is, therefore, the main production resource for processing a job operation. This is a simple or complex process executed in a single stage of processing, within the same workstation processing set-up. Workstations, in addition to processors may also have and use auxiliary resources, e.g. tools. Although, frequently, a workstation has only a single processor, there are many manufacturing environments where workstations require more than one processor for job operation processing. Examples of processors are machines or even operators. When machines are the processors, then required operators may be seen as auxiliary resources.

The α class of parameters, which will be used to codify the production systems' environments, is based on two subclass namely $\alpha 1$ and $\alpha 2$. $\alpha 2$ simply expresses the number of processors in the system. The class $\alpha 1$ of parameters characterizes and describes the production environment, namely identifying the number of stages of processing, work flow patterns, workstation formation and functional workstation grouping. The flow patterns that can be defined are constructs and combinations of the basic flow patterns that can be envisaged, resulting from possible movements of work between workstation within a workstations' layout setting. Such movements include: repeat, in-sequence, bypassing and backtracking [14].

The structure and meaning of the class α of parameters although bearing similarities to the notation proposed by Graham et al [6] and to other notations, are quite different. Based on the characteristics and requirements codified by the class α of parameters referred the ontology here proposed falls under four major classes of production system' environments, i.e., G, GM, GF and GFM, table 1. These are the values of the first of the $\alpha 1$ class of parameters, here called the general system structure parameter g.

Production Systems Environments	$\alpha 1{:}g$
General system	*G*
General flexible system	*GF*
General system with multi-processor operations	*GM*
General flexible system with multi-processor operations	*GFM*

Table 1 – Major classes of production systems environments in scheduling problems

G stands for a general system environment that can process jobs with one or more operations in whatever sequence they are required in each job having and using for each operation a specific single processor workstation and, if required, auxiliary production means. We can name the G production environment simply as general system or, more comprehensively as general system for single processor operations. This environment has been referred as general shop by Brucker [7] and as open shop by Baker [9].

The class GF extends the class G in a perspective of workstation replication and consequently processors replication, creating functional groups of processors or, in this case, workstations, for carrying out job operations as in G. This means that instead of having only a workstation for processing a specific operation or task that requires a single processor, we may have a group of parallel workstations with the same operation processing capability. This means that the operation of the job may be performed in whatever equivalent processor or workstation that may be available. This environment can be referred as the general flexible production system environment, or simply general flexible system, for short. An alternative name could be general hybrid production system environment.

The class GM also extends the G class but to a situation where the processing of an operation may simultaneously require one or more processors, a possibility that is not available in the two previous environments. Thus, in this production environment there is a need for grouping processors to form workstations. This general class of systems is called general system with multiprocessor operations.

Both the GM and GF production systems environments include G, i.e. this is a special case of each one.

The last major class of production environment, the GFM, combines GF and GM leading to what we call a general flexible system with multiprocessor operations. This includes all the three previous referred classes.

As we see, each environment evolves to others through either a generalization or a restriction process. Restricting GF to a situation where only a single processor or workstation exists per processing stage leads to G environment. Generalizing GF through the possibility of having workstations with multiprocessors, for multiprocessor job operations, leads to GFM. This generalization-restriction strategy is explored throughout the production systems environments described by the ontology here proposed.

It is clear that some scheduling problems are not so general that need to be associated with the highly generalized GFM environment or even with any of the less generalized system environments identified. Moreover, there are many scheduling methods that are specific and only to be used for solving scheduling problems in some special cases or subclasses of the general systems environments identified in table 1. Therefore, it is required that major subclasses of the general systems are identified which fit the set of constraints of several scheduling methods or algorithms available to solve scheduling problems.

Table 2 shows the common subclasses of the general system class G, represented by a nomenclature which partially shares notations generally adopted in the theory of scheduling. Therefore, in addition to the general system structure parameter further parameters within the class $\alpha 1$ are required for subclass identification. Initially we define the job processing stages parameter s that can take two values, namely s1 and sm. s1, standing for single stage environments, is used to characterize environments that process only jobs with a single operation, processed in a single stage, and sm for those environments processing jobs that may have more than a single operation, i.e. multi stage system. So, multi-stage systems are associated with environments that need processing jobs, not necessarily all, with two or more operations. If an integer value greater than one, is specified form, this defines the limit to the number of operations or processing stages that a job may have to follow. In addition to these, further parameters are required to fully identify and characterize a production system environment. Another parameter following s, and represented in table 2, here referred as the work flow pattern parameter, f, which may take values such as P, PI, PU, PN, O, OP, J, JP, F, and FP, permits identifying the operations relative allocation to production system workstations, operations processing sequence of each job and workflow structure in the production system. This combines all four or some of the basic flow patterns identified by Aneke and Carrie [14].

The number of processors, expressed by $\alpha 2$ has also to be defined to fully characterize the production system environment where the scheduling occurs. If the number of available processors in the system can be any, then $\alpha 2$ takes the default value "$\varnothing$", or simply its value is omitted, meaning that any number of processors, can be available. Alternatively $\alpha 2$ can take an integer value k. In this case, k processors are available in the production system for job processing. According to production system environment and job operation processing requirements, there may be a need to duly combine them into multiprocessor workstations or groups of parallel workstations, or both.

Class number	Parameter designation	α parameters:
	Production system environment ($\alpha 1$):	g/s/f
G1	General system	*G*
G2	Single-stage, single-processor	*G/s1*
G3	Single-stage with parallel processors	*G/s1/P*
G4	Single-stage with identical parallel processors	*G/s1/PI*
G5	Single-stage with uniform parallel processors	*G/s1/PU*
G6	Single-stage with unrelated parallel processors	*G/s1/PN*
G7	Multiple-stage	*G/sm*
G8	Job shop	*G/sm/J*
G9	Pure job shop	*G/sm/ /JP*
G10	Flow shop	*G/sm/F*
G11	Pure flow shop	*G/sm/ /FP*
G12	Open shop	*G/sm/O*
G13	Pure open shop	*G/sm/OP*
	Number of processors ($\alpha 2$)	$\varnothing$,*k*

Table 2 – Subclasses of the general production system environment *G*

In addition to the general system G, numbered as G1, and previously described, a set of subclasses, G2 to G6, table 2, can be identified. These are associated with single stage processing jobs to represent the single stage single processor system G/s1 and four system variants of the parallel processor environment, namely the parallel undefined or general G/s1/P and the cases of identical, (PI), uniform (PU) and unrelated (PN) parallel processors.

In addition to G1, classes numbered G7 to G13 cover the cases where jobs in the system may have more than a single operation or processing stage per job and single processor workstations are used for each stage. Usually at least one job having two or more operations is expected to be processed in the system. Two situations can be identified: one in which jobs with two or more operations have a rigid and unique operations precedence between them, i.e. linear operation precedence, and another in which they do not. The first situation covers variants of the job shop environment, i.e. cases G8 to G11 which includes the two flow shop cases, as show in table 2. The second covers the two open shop cases, G12 and G13. Case G7, i.e. G/sm, refers the general multi-stage system environment with an unspecified number m of processing stages per job. A specified integer value of m means the maximum number of job processing stages allowed. In the G/sm environment we can mix together jobs with single and multi-operation with any precedence relation structure. For example jobs which may have operations with linear rigid sequence, i.e. strictly ordered sequence, with others with flexible operations' precedence relations or none. Flexible precedence means that all or some operations of a job may have alternative precedence relations. Case 8, G/sm/J refers the job shop environment giving to work flow pattern parameter f the value J. Here, jobs may have variable number of operations with a specific linear precedence relation between operations, i.e. operation oi always precedes operation oj, to be performed in the workstations of the system through routings that may be different. A routing indicates the order in which the workstations are visited for processing the operations of the job. If each job has the same number of operations as there are processing stages in the system, performing each operation in a different stage, and therefore in a different workstation, we have what here we call the pure job shop, with parameter f taking the value JP. Baker [9] refers to this environment as the classical job shop and gives the name of pure job shop to what Conway et al [5] call randomly routed job shop. This is a job shop subject to random choice of machines, from the set of m different machines available, for processing the required operations of jobs. This particular case is included in the more general G8 job shop environment, here coded as G/fm/J. This concept was coined as job shop-general case by Baker [9], general job shop by Conway et al [5] and job shop with machine repetition by Brucker [7]. It is important to emphasize that here we consider G/fm/J to represent the general case of job shops where both machine repetition and job recirculation is allowed. Machine repetition means that two successive operations may be performed in the same workstation. Job recirculation means that a job can visit more than once a workstation to process operations that are not necessarily consecutive in a linear operation precedence relationship. There are situations where machine repetition or job recirculation, or both, are not allowed. These are constraints that can be dealt with by the ontology within the β class of parameters, i.e. that of job and resources characteristics and constraints.

If the routings are such that in-sequence flows result from stage to stage, according to job routing, we have the special case of job shop known as flow shop, G/sm/F. This is named by Baker [9] as general flow shop and by Norton and Pentico [15] as skip flow shop. If, in this case, all the jobs have the same number of operations, and therefore the same routing, the pure flow shop G/sm/FP results. Again, there is not unanimity in the academic community about the name, e.g. Baker [9] agrees with the name pure flow shop, but Brucker [7] and Conway [5] simply names the concept as flow shop.

We can conclude that in G/sm/J and G/sm/JP shops there can be backtracking workflows in a given workstation layout setting in the factory floor, while, in G/sm/F and G/sm/FP shops there cannot. Figure 1 makes a representation of workflows in such shops, and also in the two open shop cases. In these two latter environments (see table 2), jobs may have operations where precedence relations do not exist. Thus, the pure open shop, case G/sm/OP, can be seen as deriving from either the pure job shop G/sm/JP or pure flow shop G/sm/FP, where precedence relations among all operations of the job cease to exist. Therefore, each job has a number of operations identical to the number of processing stages in the production environment, with each operation allocated to each of the different available workstations, but without precedence relation among job operations. The G/sm/O environment is similar to G/sm/OP but with variable number of operations per job.

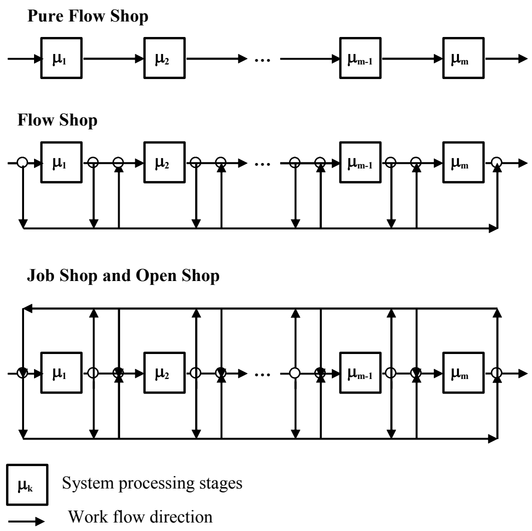

Fig. 1. Figure 1 Work flow in job shops, open shops and flow shops (adapted from Baker [9])

Table 2 shows the production systems' environments identified for the case of the general system G. Equivalent environments can be specified based on the other three classes of general systems, namely GF, GM and GFM. The difference for GF is that, some or all workstations are now replicated. A situation not verified in the G cases. All the same remains identical. So instead of having G as the value of the 1st parameter of the $\alpha1$ class, i.e. the general system structure parameter, we have now GF. The same can be said respectively for GM and GFM having in consideration the meaning above explained for the classes GM and GFM of production environments. Therefore, in all we can identify a quite large number of production systems' environments of scheduling problems. It is worth to point out here that the processors specified by $\alpha2$ are allocated to the production systems' workstations. Thus, for the G and GF based environments, each workstation has a single processor. However, in the GM and GFM based environments more than one processor are made available in some or all workstations, depending on the specific environment that is considered.

EXAMPLES

Example 1: $\alpha1=G$; $\alpha2=1$

This is a general system which has a single machine workstation but can process jobs with one or more operations without any particular sequence. Clearly this requires the machine to process different operations of the same job and, therefore, machine repetition is allowed. In this case two consecutive operations of the same job are performed in the same machine.

Example 2: $\alpha1=G/s1$; $\alpha2=\varnothing$

This is a general system that processes jobs in a single stage of processing. It represents both systems with a single processor, usually associated with single machine scheduling problems, and also undefined parallel machine systems.

Example 3: $\alpha1=G/s1$; $\alpha2=1$

This is clearly a production systems environment that processes jobs in a single stage of processing with a single machine. Thus, it represents the classical single machine scheduling problem.

Example 4: $\alpha1=G/s1/P$; $\alpha2\geq2$

Any general system for processing single operation jobs in any available equivalent parallel machines.

Example 5: $\alpha1=GM/s1$; $\alpha2\geq2$

Similar to $G/f1$, $\alpha2=\varnothing$ referred in example 2 but considering that some or all the jobs may require two or more processors, for carrying out their operation.

Example 6: $\alpha 1=GFM/s1$; $\alpha 2\geq 2$

This is similar to example 5, i.e., $GM/s1$ $\alpha 2\geq 2$, with the great difference that more than a single equivalent workstation, i.e. parallel machines can be available to process single stage processing jobs. In the extreme case of $\alpha 2=2$ jobs requiring only one processer have a parallel system with two processors. Considering that some will require two, a single double processor workstation will be available built with the two processors. These two grouping possibilities of the two processors must be possible to elect the production environment as $\alpha 1=GFM/s1$; $\alpha 2\geq 2$.

Example 7: $\alpha 1=G$; $\alpha 2=\emptyset$

This is a general system which can have any number of machines processing jobs with one or more operations without any particular sequence. Machine repetition and job recirculation, i.e. a job may visit a machine more than once.

Example 8: $\alpha 1=G/sm$; $\alpha 2=\emptyset$

This is almost identical to the previous case having the requirement that at least one job needs two or more stages of processing.

Example 9: $\alpha 1=G/s2$; $\alpha 2=\emptyset$

This is a general system which can have any number of machines processing jobs with one or at most two operations without any particular sequence.

CONCLUDING REMARKS

The resolution of scheduling problems towards effective and efficient operation of manufacturing systems requires an effective tool for an easy and a clear definition, specification and identification of the problems to be solved and the access to suitable and good scheduling algorithms and methods, nowadays mostly available through the Internet. These requirements and access to scheduling methods can be met using a comprehensive ontology for characterizing and specifying the scheduling problems and a related and suitable notation for their easy codification. Although some ontologies and notations have been developed in the past, mostly focussed on scheduling problems specification, they are not comprehensive enough for full scheduling problem characterization and specification neither designed to be used for scheduling collaboration and methods search and access through the Internet. One of the dimensions for scheduling problem characterization is that of the production systems environment. In order to contribute to a fully comprehensive ontology for scheduling problems and easy problem specification for scheduling collaboration through the Internet, this paper presented and discussed a new ontology for production systems environments and a notation for the environment codification. Thus, a large variety of situations can be modelled with the ontology proposed covering a great variety of cases and situations that appear in practice for scheduling jobs in manufacturing systems. Moreover, the contribution here given is an attempt to consolidate and unifying concepts that have been used in the literature of scheduling and also extend them to a more comprehensive ontology useful for Internet-based support for problem solving. Although, the proposed ontology may appear complex it seems very suitable for real world scheduling problems. The nomenclature structure is based on a three field class $\alpha|\beta|\gamma$. Only the class field α, that of production systems environments dimension, was addressed. The full characterization of scheduling problems to be solved requires developing the ontology in the two other dimensions, namely those of classes β and γ for definition of task and resource characteristics and constraints and also for the optimization criteria definition. This is being done in the context of this research and will be published soon.

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TOWARDS A SITUATION ADAPTIVE SHOP FLOOR PRODUCTION

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Abstract: Customer oriented production of multi-variant products increases the dynamics and complexity of today`s production processes. As a consequence, established systems for production planning and control reach their limits, especially in the field of shop floor production. In order to stay competitive and to maintain an efficient production flow, adaptive production systems using methods from the field of artificial intelligence and innovative control strategies came into focus. This article introduces the concept of a situation adaptive shop floor production. The proposed system adapts itself to production situations, employing a two-stage procedure. First, a neural network classifies production situations depending on predefined parameters. Second, an appropriate control strategy for the perceived situation is chosen. The applicability of the approach highly depends on the variety of available control strategies. Both the classification and the corresponding strategy selection are shown by means of an example.

Keywords: adaptive systems, artificial intelligence, intelligent decision support system, job shop

INTRODUCTION

Shop floor production, as an organisational form, is characterised by the manufacturing of small series, single pieces and prototypes with short production cycles. Correspondingly, the production processes are complex and dynamic [1]. In addition, the increasing orientation towards customer specific products pushes established production planning and control systems to their limits [2].

The development of innovative control strategies and methods is a promising approach to cope with these problems. The margin reaches from new paradigms such as autonomous control [3] over biologically inspired methods such as bee or ant algorithms [4] to approaches from the field of artificial intelligence. In the latter case, often software agents [5] or artificial neural networks [6] come into operation. Systems implementing such innovative approaches are ordinarily adaptive, flexible and intelligent [7]. Unfortunately, their implementation often requires a complete and/or sophisticated redesign of the existing facilities. Therefore, a selective enhancement can be a useful intermediate step.

This contribution outlines an approach that complements a generic shop floor production with a neural classifier. This classifier conducts a clustering of production situations based on typical key figures such as capacity, inventory levels and backlogs. In a second step, an appropriate control strategy is chosen, dependent on the perceived production situation. Both enhancements, the classifier as well as the strategy selection, are implemented on the software level. Thus, complex and expensive modifications are unnecessary.

The next section introduces neural networks in general, followed by a detailed description of the applied neural classifier in section 3. Section 4 deals with the selection of appropriate control strategies and gives an example for the development of additional hybrid solutions. The evaluation in form of a material flow simulation using a generic shop floor model is described in section 5. Finally, the article closes with a summary of the obtained results and an outlook on future research in section 6.

ARTIFICIAL NEURAL NETWORKS

Artificial neural networks are mathematical models of natural neural systems [8]. They are structured as layers of nodes, which are interconnected via weighted links [6]. An artificial neural network consists of at least two layers, an input and an output layer. Between these layers, an unlimited number of so called hidden layers are possible, depending on the network type [9]. A typical artificial neuron is depicted in Fig.1.

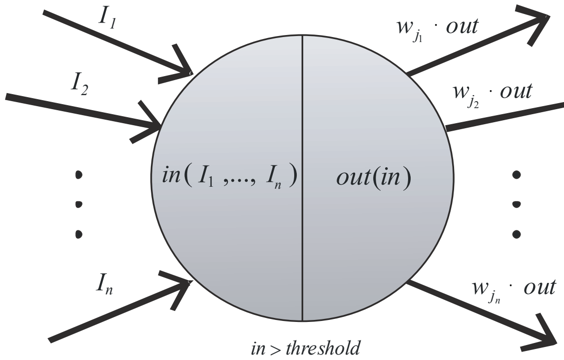

Fig. 1. Artificial neuron [10]

A typical area of application for neural networks is the approximation of mathematical coherences which are unknown or not exactly describable. In this case, the neural network acts as a kind of black box [10]. Beside the handling of complex mathematical functions, neuronal networks offer fast data processing, small modelling effort and the ability to learn from experience [11]. Thereby, the gained knowledge is stored within the link weights, which are continuously adjusted during the learning process. Depending on the type of neural network and the available data about the task which has to be learned, three types of learning procedures can be distinguished.

During *Supervised Learning,* input data as well as the desired output is presented to the neural network. Corresponding to the presented input-output relations, the network adjusts its link weights in a way that every input generates the requested output [12]. *Reinforcement Learning* denotes a procedure that only presents the input data. Instead of giving the corresponding output, the network only receives a feedback if its output is correct or not [8]. The third approach is called *Unsupervised* or *Self-Organized Learning*. Thereby, input data is presented without any feedback concerning the correctness of the calculated output [13]. This procedure aimsat an autonomous recognition of possible patterns within the input data.

In all of the three mentioned procedures, the generalization of the learned function approximation is ensured by presenting an additional set of validation data. This also prevents a simple memorising of the training data, called *Overfitting* [8].

THE NEURAL CLASSIFIER

The architecture of neural networks differs corresponding to their areas of application. Recurrent or partially recurrent networks for example, are often used for forecasting purposes, whereas self-organizing maps (SOM) are effective for classification or clustering tasks [13].

The neural classifier used within the proposed adaptive production control is such a self-organising map. This special kind of neural network consists of two layers, an input layer and a two dimensional so called competitive layer. An exemplary SOM is depicted in Fig. 2.

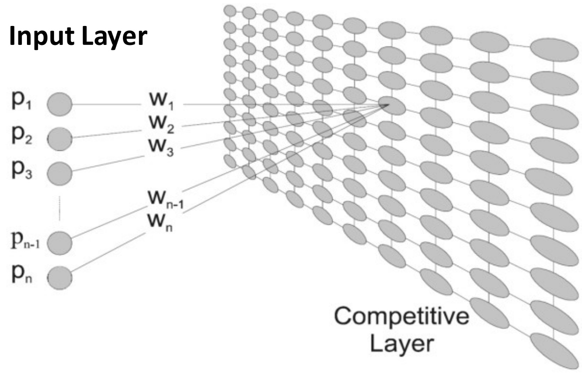

Fig. 2. Exemplarily SOM [14]

Within the competitive layer, adjacent nodes are connected with each other and to the input nodes p_1 to p_n (for clarity, this is only depicted for one competitive node on Fig. 2).

Self organizing maps are able to approximate coherences within the processed data. This is obtained through a self-organized learning procedure that strengthens the connections between nodes, which are affected by similar input vectors. At the end of the training process, the connection weights and the node activations of the competitive layer constitute a two dimensional map of the perceived relations [15].

The SOM used in the proposed concept performs a clustering of situations by reference to the three key figures capacity, inventory and backlogs. Therefore, the input layer consists of three nodes which are mapped on a competitive layer consisting of 20x20 nodes. The training data stems from simulation runs of a generic shop floor model presented in section 5. The learning procedure comprises 500 cycles, beginning with a weight initialisation following the Kohonen constant function. This function allocates every link weight a value of $\frac{1}{\sqrt{n}}$, whereby n is the number of nodes in the competitive layer.

CONTROL STRATEGIES

The adaptability of the proposed production control system is mainly based on the situation specific application of suitable control strategies. The more strategies are available, the better becomes the adaption of the controlled shop floor to changing situations. The portfolio of possible strategies depends on attributes of the regarded production system such as the production type and sequence as well as the type and complexity of the material flow. Further, variations of customer wishes and the corresponding capacity requirements are of interest. In the present case, the strategies have to fit a shop floor environment with a complex material flow including back flows as well as short and varying production cycles.

In addition, the starting points of the strategies have to be considered. To ensure a minimal effort for the implementation of the proposed system, an application of the adaptive control shall not require sophisticated changes within the shop floor. Therefore, the control system is focused on strategies using key figures, which are already captured through existing production planning and control processes. Furthermore, these key figures are the basis for the classification (see also section 3).

The presented approach considers an initial strategy pool consisting of the load-oriented order release (LOOR), the backlog control, the decentralised WIP-oriented manufacturing control (DEWIP) and the deadline-oriented capacity control. To improve the applicability of the situation adaptive approach, it is necessary to assess the suitability of these strategies to certain situations. Furthermore, the handling of situations, which are not sufficiently covered yet, requires a constant extension of the strategy pool. For example, merging two or more established approaches to hybrid solutions could be promising. In the following, the combination of load-oriented order release and backlog control shall serve as an example for this proceeding. The resulting hybrid is evaluated in comparison with its partial strategies in section 5.2.

The LOOR releases orders within the manufacturing system with regard to inventory limits [16]. The scheduling takes place in a central manner, directly before the order release. It comprises three steps. First, a possible urgency of the current order is checked by means of back scheduling. If an order has to be processed within a certain look-ahead time, it is marked as urgent and its release is preferred. Otherwise, the current order is deferred for a period, which is usually about half of the look-ahead time. Second, an approval test evaluates the inventory limits of the machines designated for the processing of the current order. If the inventory levels fall short of the limits, the order is released in the third step or, in the case of a transgression, deferred again. At this point, the calculation of the inventory limits is as follows:

$$\mathrm{IL} = \mathrm{PS} \cdot (\mathrm{PPT} + \mathrm{LP}) \qquad (1)$$

1. IL = Inventory Limit.
2. PS = Planned Service.
3. PPT = Planned Processing Time
4. LP = Length of Period (usually ½ · look-ahead time).

The backlog-oriented approach considers the capacity of the manufacturing system as control variable. Therefore, the comparison between the actual and the desired number of completed orders serves as an indicator for capacity adaptations [17]. The adaptations take place, depending on a predefined limit for the number of backlogs. If the limit is exceeded, the capacity of the whole shop floor is increased in form of additional shifts for the employees. A lower deviation results in a corresponding capacity reduction. Ordinarily, the adaptations last for one work day.

The deadline-oriented capacity control considers possible deviations between planned and actual delivery dates [18]. If an order is in danger of missing the deadline, the capacity is adjusted correspondingly. Further, the number of deviations is continuously compared to a limit. This limit determines the sensitivity of the control and therefore the frequency of adjustments. In contrast to the backlog-oriented approach, the capacity control concerns only single work stations instead of the complete manufacturing system.

The DEWIP strategy bases on decentralised, inventory-oriented control loops located in between the work systems. It aims at short and predictable lead times [19]. In contrast to the LOOR approach, the order release is carried out individually for every working step within the production process. A work piece is only transferred to the subsequent work station, when the further processing is ensured. At this point, the order release considers the current as well as the implicit inventory level of the following work station. The implicit inventory level is as follows:

$$ImpIL = \sum_{i=1}^{n} TPT_i + PT_i \qquad (3)$$

1. ImpIL = Implicit Inventory Level
2. TPT_i = Total Processing Time for work piece *i*.
3. PT_i = Processing Time for work piece i at the previous work system.

The hybrid approach combines the LOOR and the backlog-oriented control. Both strategies influence different levels of the material flow, wherefore the combination constitutes a vertical hybrid control (VHC) [20]. The combined approach assesses the order release before the start of production and also the assembly or picking after the completion. The hybrid`s order release follows the defaults of the LOOR approach whereas the calculation of the inventory limits is adapted as follows:

$$IL = PS \cdot (APT + AST + LP) \cdot NM \quad (4)$$

1. IL = Inventory Limit.
2. PS = Planned Service.
3. APT = Average Processing Time.
4. AST = Average Setup Time.
5. LP = Length of Period (usually ½ · look-ahead time).
6. NM = Number of Machines/Shop floor sections, the order has to pass.

In case of a flexible processing sequence, the considered inventory levels are calculated for those sections of the shop floor, the order has to pass. While the order release, following the LOOR approach, influences the inventory levels within the shop floor, the capacity adjustment follows the settings of the backlog control. Dependent on a cyclic backlog measurement, the capacity is progressively increased in form of additional working hours for the following day. Thus, the control principle focuses on the temporal aspect of capacity.

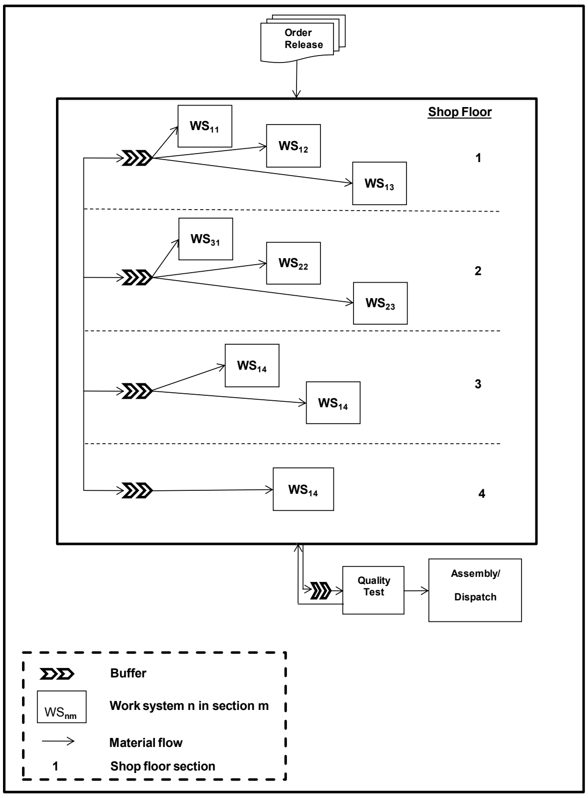

Fig. 3. Generic shop floor model

EXPERIMENTAL RESULTS

The evaluation of both the neural network based classification and the situation adaptive choice of the control strategy takes place by means of a generic shop floor model. The model consists of 9 work systems distributed over 4 sections with a buffer in front of each section. The redistribution between different shop floor sections follows the machining sequence. The corresponding choice of the suitable workstation takes place according to simple priority rules. Further, the work pieces pass a quality test subsequent to the last production step. If the test procedure is successful, the work piece is assembled to the end product and/or dispatched. In case of a quality defect, the work piece returns to the shop floor as a new order. Within the model, 10% of the manufactured work pieces are considered as defect. Fig. 3 shows a schematic view of the modelled shop floor. The evaluation is split up into two simulation runs, one for the classification and one for the changing application of control strategies.

Classification

The classification bases on simulation runs of 50 days each. Within this interval, 6 different work pieces are manufactured, the average number of orders per day amounts to 220. The size of the homogeneous lots fluctuates among 3-5 work pieces. A working day lasts 16 hours altogether, split up into two work shifts of 8 hours, including a break of 1 hour. A cyclic recording of the three parameters capacity, inventory and backlogs provides the necessary training and validation data for the applied SOM. The period length for the recordings is oriented towards the shortest possible throughput time for all manufactured work pieces.

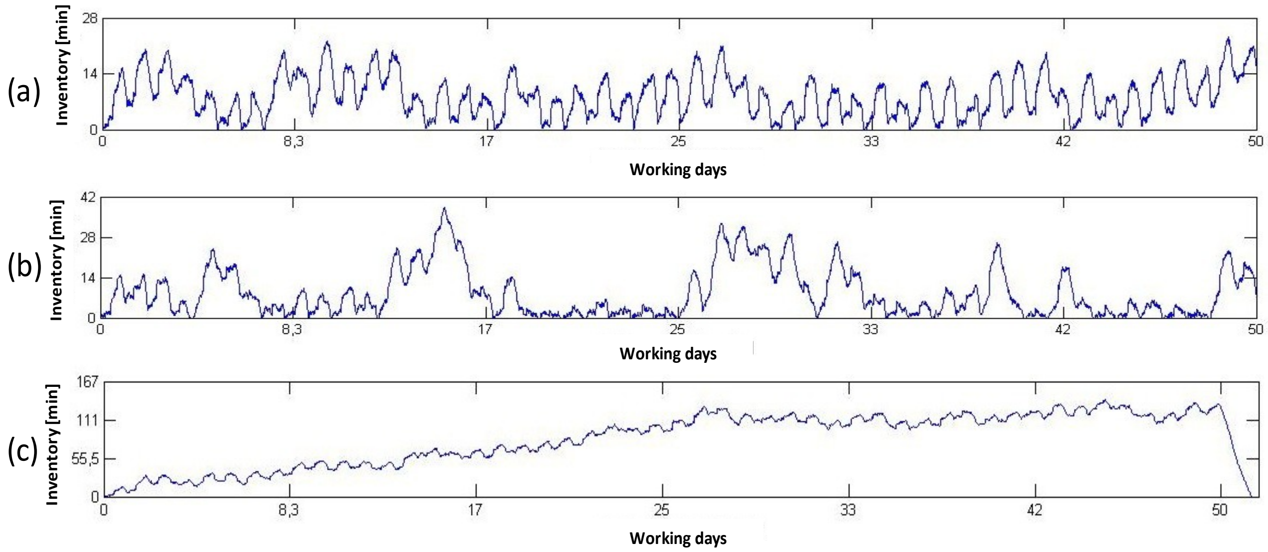

Fig. 4. Inventory levels in comparison

Overall, the data base is comprised of approximately 6000 discrete-time records. The simulation runs result in the classification of three different production situations. Fig. 4 shows the corresponding inventory levels. The course of the inventory levels allows a clear distinction. Nevertheless, the similar average inventories of situation a) and b) justify the consideration of three parameters. The additional involvement of backlogs (Fig. 5) and capacity (not depicted for reasons of clarity) generates a situation specific fingerprint. This fingerprint enables a correct classification, even when one or two of these parameters show a similar behaviour. The fingerprint is further mapped to the competitive layer of the applied SOM. At this point, the activations as well as the connection weights within the layer reflect the learned coherences between the parameters. Fig. 6 shows the resulting SOMs for the three classified situations. The classification generates higher activated nodes and differing link weights (bright areas) as well as completely unaffected nodes and links (dark areas). As the latter is also the case for the other perceived situations, a sufficient classification with less competitive neurons might be possible.

However, to cover situations with more complex coherences and/or a consideration of additional parameters, a 20x20 matrix seems suitable. A closer analysis of the classification results a) and b) shows accordances regarding the activations depicted. This corresponds to the similar average inventory levels of both situations. The small but still significant distinctions result from the different numbers of backlogs within the considered period. The third classification result draws a different picture. Here, the SOM mapping shows a completely different layout. Situation c) features deviant inventory levels but resembles situation b) regarding the backlogs.

In summary, it can be said that the applied

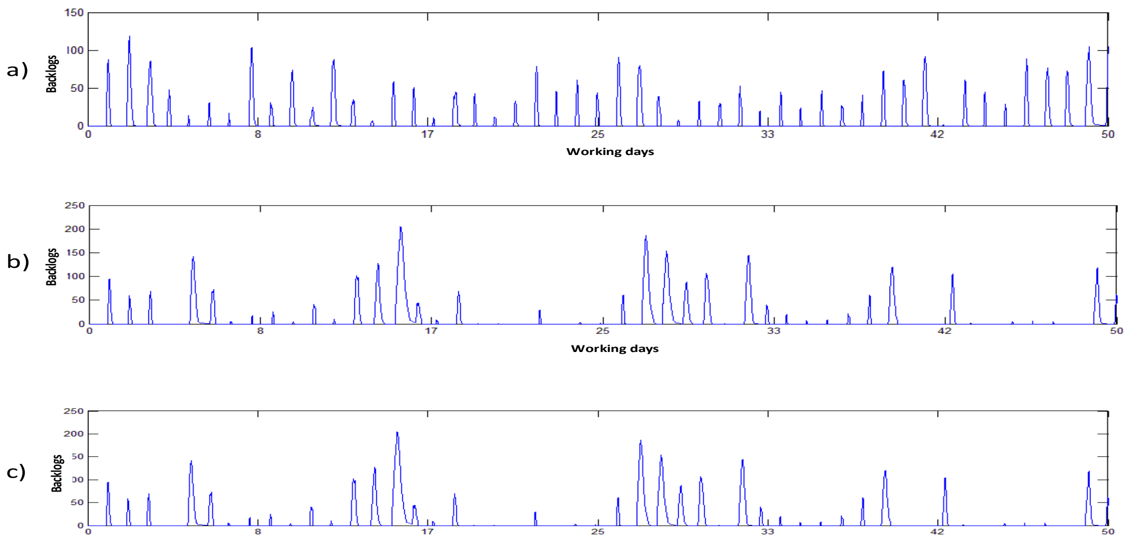

Fig. 5. Number of backlogs in comparison

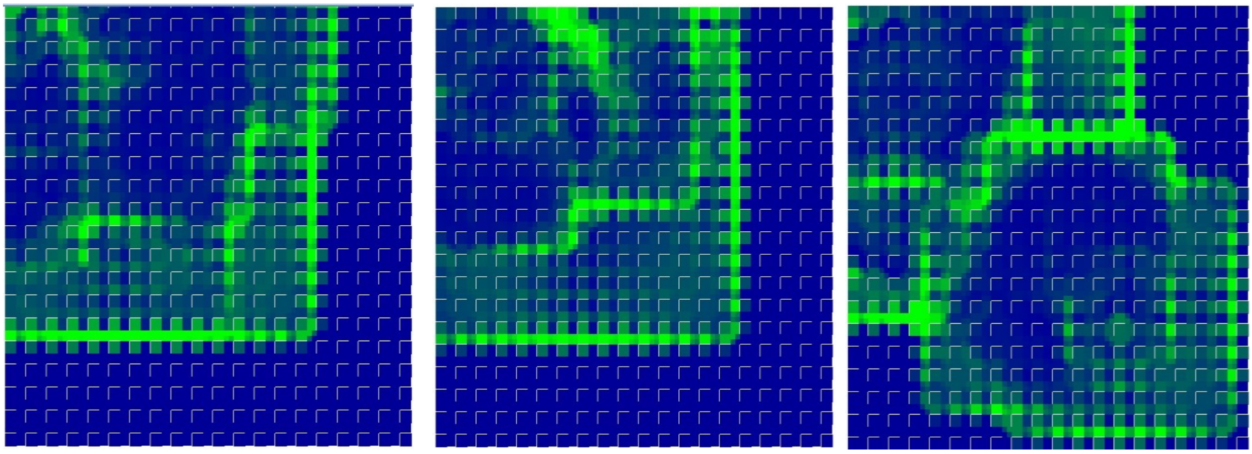
Fig. 6. Competitive layer of situations a), b) and c) in comparison

neural classifier is capable of distinguishing the conditions of a generic shop floor by reference to the three parameters inventory, capacity and backlogs. The following subsection deals with the results of a situation specific selection of control strategies.

Selection of control strategies

The strategy selection is evaluated in a simulation run lasting one year. During this period, 44305 orders pass the shop floor, whereas four order situations occur, with three months each. These situations differ in order number, individual order size and the range of different work pieces produced. This reflects short innovation and production cycles, which are typical for a shop floor. During the simulation period, a maximum of six different work pieces is produced. The distributions of the work pieces are liable to the normal distribution, whereas the average and the standard deviation differ. The experiments cover the complete range of the initial strategy pool. The following closer evaluation is focused on the hybrid introduced in section 4 and its partial strategies. The remaining strategies show unsatisfactory results for the considered test period. In a real scenario, they would not be applied.

The performance of the three strategies is measured by means of the inventory levels and lead times. Fig. 7 shows the inventory levels during the simulated time frame. The calculation bases on the weekly average of the inventories measured in all sections of the shop floor. The depicted inventory development reflects the four order situations, which last approximately 13 weeks each. In the first half of the year, all strategies reach irregular inventory levels, followed by a joint peak in the third quarter. The reduction of the high inventory levels dominates the last period of the simulation. The hybrid solution achieves an average inventory level of 14,55 minutes, the load-oriented control is around 66 minutes and the backlog control around 47,5 minutes.

The lead times follow a similar course with average levels in the first half-year, a peak in the third quarter and a downward curve in the last quarter (see Fig. 8). The average lead time of the hybrid is around 52 minutes. This is clearly below

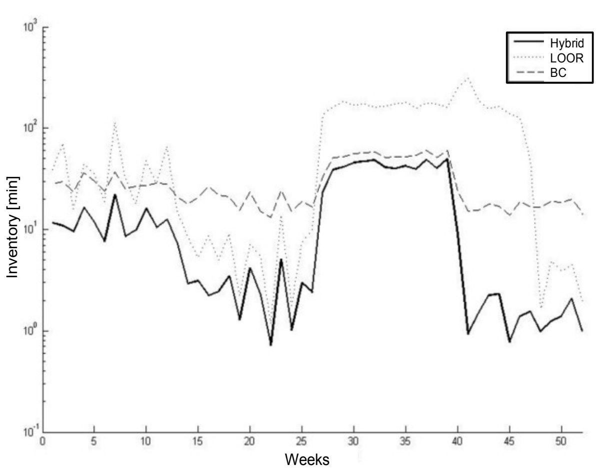

Fig. 7. Inventory levels in comparison

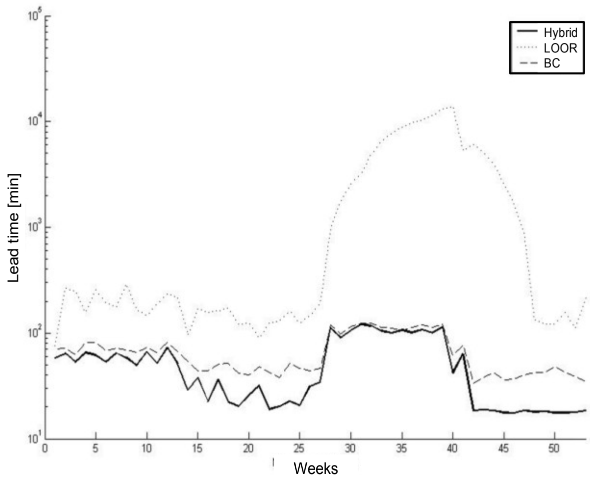

Fig. 8. Lead times in comparison

the 68 minutes of the backlog control and the 2634 minutes achieved by the LOOR. The extreme values for the LOOR are caused by frequent deferments due to reached inventory limits.

The overall analysis indicates advantages for the hybrid control strategy for the two situations in the second half of the simulation period. A situation based application of the available strategies would depend on the trade-off between the effort for the change and implementation of the individual approaches and the expected benefit. With regard to the possible costs, the hybrid solution is certainly useful within situations which are similar to the third quarter.,In these situations the higher implementation effort is compensated by the highest benefit. The backlog control yields presentable results during the first quarter. Reasonable inventory levels and lead times are indicative for this strategy. Finally, the LOOR indicates a suitability for the second quarter. At this point, the strategy achieves good inventory results and justifiable lead times.

CONCLUSION AND OUTLOOK

The presented approach of a situation adaptive shop floor control bases on two aspects, the classification of production situations and the corresponding choice of a suitable control strategy. Both components are already disposable at the academic level. The experimental results show that a neural classifier, namely a self-organizing map, is able to distinguish and classify states of a generic shop floor production. These states can be seen as production situations, differing in the characteristic of the underlying parameters. The applicability of a corresponding strategy selection mainly depends on a broad pool of possibly applicable strategies. Hybrid solutions can bridge gaps between the established available approaches.

Future work should focus on the mapping between existing strategies and classified situations. Identified gaps have to be closed by newly developed strategies and/or hybrid combinations of known approaches. Further, the organizational integration of a dynamic strategy change into the daily business of a shop floor is of interest. Finally, a cost-benefit model for the final decision between similarly suitable strategies for a production situation is necessary.

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A REDUCTION METHOD FOR NONLINEAR SEMI-INFINITE PROGRAMMING BASED ON AN EXACT PENALTY TECHNIQUE

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Abstract: Semi-infinite programming (SIP) problems arise in several areas of engineering, such as robot trajectory planning, production planning, design of digital filters, and air pollution control. While there are a wide range of applications, there is not much software available. The only available SIP solvers are the *fseminf* MATLAB function, FSQP and NSIPS, but none of these solvers provide an algorithm belonging to the class of reduction type methods. In this article we propose a reduction type method, based on a penalty technique to solve SIP problems. We report numerical results with 117 test problems from the SIPAMPL database, using a MATLAB implementation of the proposed algorithm, which we coined as SiRedAl.

Keywords: Semi-infinite programming, reduction type algorithm, penalty function.

INTRODUCTION

Semi-infinite programming (SIP) problems arise in several areas of engineering, such as robot trajectory planning [1,2], production planning [3], Chebyshev approximation theory [4,5], design of digital filters [6,7], and air pollution control [8,9].

Although there are several algorithms for SIP proposed over the last decades, there is not much publicly available software. The *Feasible Sequential Quadratic Programming* (FSQP) [10] incorporates a special scheme to deal with discretized SIP problems that often have a big number of constraints. The MATLAB *fseminf* function is available on the Optimization Toolbox [11] and this function addresses SIP problems with a maximum two dimension infinite space. The *Nonlinear Semi-Infinite Programming Solver* (NSIPS) [13] is publicly available and in its current version implements four algorithms for SIP. All implemented algorithms consider only problems with infinite constraints, and none of them belonging to the class of reduction type methods.

The wide application of SIP jointly with the need of available software motivates the proposal and implementation of an algorithm. The proposed algorithm addresses SIP problems in the most general form, including equality and inequalities constraints, using an algorithm belonging to the class of reduction type methods.

A SIP problem can be described, in a general form, as follows:

$$\begin{aligned} &\min_{x\in\Re^n} f(x) \\ s.t.\ & g_i(x,t)\le 0 \quad i=1,\ldots,m \\ & h_i(x)=0 \quad i=1,\ldots,o \\ & h_i(x)\le 0 \quad i=o+1,\ldots,q \\ & \forall t\in T\subset \Re^n, \end{aligned} \qquad (1)$$

where T is an infinite set, usually a cartesian product of intervals with finite bounds, i.e., $T=[\alpha_1,\beta_1]\times[\alpha_2,\beta_2]\times\ldots\times[\alpha_p,\beta_p]$. The objective function is denoted by $f(x)$, the constraints $g_i(x,t)\le 0,\ i=1,\ldots,m,$ are called the infinite constraints, since they must be satisfied for all $t\in T$, and $h_i(x)=0,\ i=1,\ldots,o,$ $h_i(x)\le 0,\ i=o+1,\ldots,q,$ are the finite equality and inequality constraints, respectively. A problem is said to be of the SIP type if it has at least one infinite constraint, i.e., if we have $m>0$. We assume that all functions are, at least twice, continuous differentiable in all arguments.

SIP problems are characterized to have a finite number of variables subject to an infinite number of constraints, or an infinite number of variables subject to a finite number of constraints. In this work we handle problems with a finite number of variables subject to an infinite number of constraints.

The intuitive way to solve the SIP problem (1) consists in replacing the infinite set T by a finite one. There are several ways of doing this, leading to several classes of methods. We emphasize the three main classes: discretization, exchange and reduction type methods [9,14].

Reduction type methods are characterized by the need to compute all the global solutions of the auxiliary problems

$$\max_{t \in T} g_i(\bar{x}, t) \quad (2)$$

for each $i = 1, \ldots, m,$ and a given $\bar{x}$.

The extra burden to compute all the global solutions to problems (2) is compensated by the good theoretical properties of the reduction type methods.

In the next section we present the proposed reduction type algorithm based on a penalty technique. The third section shows some numerical results, and we conclude in the last section.

PENALTY TECHNIQUE

Penalty techniques are a possible strategy to solve constrained optimization problems. The simplicity and adaptability to problems with many constraints are two important characteristics of these techniques.

Penalty methods solve a constrained optimization problem by solving a sequence of unconstrained optimization problems. Under mild assumptions, the sequence of unconstrained optima converges to the constrained optimum.

In the next subsection we will present the reduction type algorithm based on the penalty technique.

Penalty function

A previous work [15] addressed the study of the best penalty function for SIP problems, without considering equality and inequality finite constraints. The study was performed using penalty functions based on the standard 1, 2 and ∞ norms.

The penalty function, reported to obtain the best numerical results, is based on the ∞-norm and, therefore, we further extend it to include equality and inequality finite constraints, resulting in

$$\bar{\phi}_P(x, \mu, \nu) = f(x) + \mu \bar{\theta}_\infty(x) + \frac{1}{2}\nu^2 \bar{\theta}_\infty^2(x), \quad (3)$$

where $\mu > 0, \nu \geq 0,$

$$\bar{\theta}_\infty(x) = \max\left(\max_{1 \le i \le m} \max_{t \in T} [g_i(x,t)]_+, \max_{1 \le i \le o} |h_i(x)|, \max_{o+1 \le i \le q} [h_i(x)]_+ \right)$$

and $[z]_+ = \max\{0, z\}$.

The penalty algorithm

The penalty algorithm is divided into two types of iterations: internal and external.

The internal iterations are related to minimizing the penalty function for a given fixed value of μ and ν.

The external iterations are related to solving sub-problems formed by the penalty function $\bar{\phi}_P$, parameterized by μ and ν.

To evaluate $\bar{\theta}_\infty(x)$, and consequently the penalty function (3), the global solutions of problems (2) must be computed. These computations are done in the external iterations.

The sequence $\{x^k\}$, where k is the external counter iteration, is formed by

$$x^{k+1} = \arg \min_{x \in \Re^n} \overline{\phi_P}(x, \mu, \nu). \quad (4)$$

If the stopping criterion is verified (i.e., x^{k+1} is a feasible point and the relative error is smaller than a certain small value ε) then the algorithm stops with an approximation to the solution of problem (1), otherwise the penalty parameters are updated and a new external iteration begins.

Initialization of the penalty parameters

The penalty parameters initialization takes into account the initial guess infeasibility. This initialization is expected to balance the objective function and penalty term contributions to the penalty function.

The infeasibility is calculated by computing the sets A_i^0, for $i = 1, \ldots, m$, formed by the optimal solutions (all global and some local optima) for problems (2), at the first iteration. If the lower value of violations of all constraints is below a certain small value then the initial value of μ is 1. Otherwise, μ is the absolute value of the quotient between the objective function at x^0 and the lowest constraint violation. The penalty parameter μ is initialized according to the following algorithm:

Algorithm 1: Initialization of the penalty parameter μ

Let

$$\xi = \min\left(\min_{\substack{i\in\{1,\ldots,m\} \\ t\in A_i^0}} \left[g_i\left(x^0,t\right)\right]_+, \min_{1\le j\le o}\left|h_j\left(x^0\right)\right|, \min_{o+1\le j\le q}\left[h_j\left(x^0\right)\right]_+ \right).$$

If $\xi \approx 0$

then set $\mu = 1$,

otherwise set $\mu = \left|\dfrac{f\left(x^0\right)}{\xi}\right|$.

The penalty parameter ν is always initialized as 1.

The following algorithm is used to update the penalty parameters of the penalty function (3).

Algorithm 2: Updating the penalty parameters μ and ν.

If $\overline{\theta}_\infty\left(x^{k+1}\right) \le \widetilde{\theta}$, where $\widetilde{\theta}$ is a given parameter

then set $\mu^{k+1} = n\times\left(\mu^k + \nu^k\overline{\theta}_\infty\left(x^{k+1}\right)\right)$ and $\nu^{k+1} = \nu^k$

Otherwise set $\mu^{k+1} = \mu^k$ and $\nu^{k+1} = \dfrac{n\times\left(\mu^k + \nu^k\overline{\theta}_\infty\left(x^{k+1}\right)\right)}{\overline{\theta}_\infty\left(x^{k+1}\right)}$

We are now in position to present the complete penalty algorithm.

Algorithm 3: Penalty algorithm

1. Let *maxiter* be the maximum number of external iterations allowed.
2. Let x^0 be an initial guess for problem (1). Set $k = 0$.
3. Compute the sets $A_i^k, i = 1,\ldots,m,$ containing all global and local maximizers for problem (2), with $\overline{x}$ replaced by x^k.
4. Determine μ^0 using Algorithm 1 and let $\nu^0 = 1$.
5. Use x^k as an initial guess to solve the unconstrained penalty optimization problem

$$\min_{x\in\Re^n} \overline{\phi_P}(x,\mu,\nu)$$

where the set T is replaced by $A_i^k \cup E$ in $\overline{\theta}_\infty(x)$. E is a stabilization grid (grid uniformly distributed in R^p).

Let $x^{k+1} = \arg\min \overline{\phi}_P(x,\mu,\nu)$ be the obtained minimizer of the penalty function.

6. Check for x^{k+1} feasibility by computing the sets $A_i^{k+1}, i = 1,\ldots,m,$ (solving problems in (2) with $\overline{x}$ replaced by x^{k+1}).

If x^{k+1} is feasible and its relative error is less than some small value ε:

- then stop with x^{k+1} as an approximate solution to problem (1).
- otherwise update the penalty parameters according to Algorithm 2.

7. Let $k = k+1$ and go to step 5.

COMPUTATIONAL RESULTS

We implemented a MATLAB [12] version of the proposed reduction type algorithm. The solver developed is coined as SIRedAL (Semi-Infinite Reduction Algorithm). The infinite dimension is limited to 2 ($p \le 2$) in the current implementation.

The SIRedAL uses the MLOCPSOAm [16] and MLOCGAMO [17] solvers for addressing the multi-local problems (2).

MLOCPSOAm stands for the Multi-LOCal Particle Swarm Optimization Algorithm, where the last m refers to the MATLAB version. The MLOCPSOAm solver uses a stochastic algorithm (particle swarm) combined with a local procedure to enforce convergence for all the global and local optima. It is a population algorithm where a quasi-Newton direction is used to accelerate convergence to local optima.

MLOCGAMO is a genetic algorithm with some adaptation in order to determine all solutions of problems (2). This solver has two versions implemented. We use the default one, which uses a multi-objective strategy.

Whenever possible these solvers use as initial population the delta global approximations (the set $\left\{t\in A_i^k : g_i\left(x^k,t\right) > \delta\right\}$) determined in the previous iteration.

The fminsearch MATLAB function is used to solve the unconstrained problem, which uses a modified Nelder-Mead algorithm.

The stabilization grid E used in replacement of the set T, together with the sets A_i^k, for $i = 1,\ldots,m,$ is static and consists of 10 points evenly distributed for each dimension. In the implementation the stabilization grid is produced for a maximum of dimension 2.

The set of test problems are the ones available at the SIPAMPL database [18]. The SIPAMPL provides to the scientific community (among other features) a database of SIP problems coded in the AMPL modeling language [19]. The database contains more than 160 SIP problems of small/medium size. The SiRedAL solver was tested with all problems which had infinite dimension less than or equal to 2. Another functionality available on the package is an interface between AMPL and MATLAB. The SiRedAL uses SIPAMPL routines to solve SIP problems in the AMPL format.

We depict, in the following sections, the results obtained with the SiRedAL solver, where the two multi-local solvers (MLOCPSOAm and MLOCGAMO) were used. The parameters considered in MLOCPSOAm and MLOCGAMO are: a population of 100 points, a maximum allowed of 2000 objective function evaluations, and a maximum allowed of 2000 iterations. We compared the results obtained by SiRedAL with known solutions in literature. We used 117 test problems, 5 of which contain finite constraints.

The maximum number of external iterations was set to 200. In algorithm 2, $\widetilde{\theta}$ was set to 0.1 and in Algorithm 3, ε was set to 10^{-3}.

Computation results using MLOCPSOAm

Since MLOCPSOAm is a stochastic algorithm we made 10 runs for each problem. In each run, we compared the solutions with the solution available in the literature. Table 1 presents the problem name and the number of successes obtained for each problem. We consider a success when the relative error between the obtained and available solutions does not exceed 5%.

Problem	Suc	Problem	Suc	Problem	Suc
andreson1	10	kortanek1	10	lin2	10
blankenship1	10	kortanek2	10	liu1	10
coopeL	10	kortanek3	5	liu2	10
coopeM	10	kortanek4	10	liu3	7
coopeN	10	leon1	0	lobianco1	0
deluca1	10	leon10	10	matlab1	0
deluca2	10	leon11	10	matlab2	0
fang1	10	leon12	10	priceK	10
fang2	6	leon13	10	reemtsen2	10
fang3	7	leon14	10	reemtsen3	0
ferris1	0	leon15	10	reemtsen4	0
ferris2	10	leon16	0	watson1	10
goerner1	3	leon17	10	watson10	10
goerner2	0	leon2	0	watson11	10
goerner3	0	leon20	10	watson12	0
goerner4	0	leon21	10	watson13	3
goerner5	1	leon22	10	watson2	10
goerner6	0	leon23	10	watson3	10
goerner7	0	leon3	0	watson4a	10
hettich10c	10	leon4	0	watson4c	10
hettich11	0	leon5	0	watson6	10
hettich2	10	leon6	0	watson7	10
hettich5	10	leon7	0	watson8	9
hettich6	0	leon8	0	watson9	10
hettich7	0	leon9	0	zhou1	10
hettich9	0	li1	0		
honstede1	8	li2	0		

Table 1 - Number of successes using MLOCPSOAm

Observing Table 1, we verify that in 62% of the problems, the amount of successes occurred in more than half of the runs. For the hettich11 problem the algorithm did not converge in any of the runs. This problem has a quadratic objective function subject to linear constraints, therefore the penalty function corresponding to this problem is unbounded, for a fixed penalty parameter, justifying the non-convergence of the algorithm.

We report on Table 2 the results obtained for the problems whose solutions are not available in the literature. For these problems we present the average values of the objective function at the attained solution, considering a 5×10^{-3} maximum infeasibility of the infinite constraints.

Problem	Average	Problem	Average
gugat1	0.0427	polak2	6.1984
gugat2	0.1876	gugat5b	0.3972
gugat3	0.0000	gugat5c	0.2267
gugat4a	3.2041	gugat5d	0.9662
gugat4b	0.3261	gugat5e	0.0642
gugat4c	0.0417	gugat5f	0.0108
gugat4d	0.9354	gugat6	0.1103
gugat4e	1.3726	gugat7	0.5961
gugat4f	2.1077	hettich1	0.1096
gugat5a	0.0325	hettich10	1.0000
hettich13	-2.2355	hettich12	2.4590
hettich14	-2.1212	powell1	-2.9999
hettich4	1.0000	still1	1.0000

hettich8	0.0832	tanaka1	-0.9999
leon18	-1.7500	userman	0.0000
leon19	0.7952	vaz1	3665.7589
leon24	-9.4022	vaz2	0.0022
lin1	-1.8156	vaz3	6.7223
polak1	5.4450	vaz4	0.0005

Table 2 - Average objective function value using MLOCPSOAm

Computation results using MLOCGAMO

For the MLOCGAMO solver, the default bi-objective strategy is used. Since MLOCGAMO is also a stochastic solver we performed 10 runs for each problem, and the numerical results are presented in Table 3. Again, we report the number of successes for problems with solutions available in the literature. A success is also considered when the obtained solution is at a relative error of 5% with respect to the solution available in the literature.

Problem	Suc	Problem	Suc	Problem	Suc
andreson1	10	kortanek1	8	lin2	3
blankenship1	10	kortanek2	10	liu1	10
coopeL	1	kortanek3	7	liu2	10
coopeM	10	kortanek4	10	liu3	6
coopeN	10	leon1	0	lobianco1	0
deluca1	5	leon10	10	matlab1	0
deluca2	0	leon11	8	matlab2	0
fang1	5	leon12	5	priceK	1
fang2	0	leon13	10	reemtsen2	0
fang3	8	leon14	10	reemtsen3	1
ferris1	0	leon15	10	reemtsen4	0
ferris2	10	leon16	0	watson1	10
goerner1	10	leon17	10	watson10	10
goerner2	0	leon2	0	watson11	10
goerner3	0	leon20	10	watson12	10
goerner4	0	leon21	0	watson13	0
goerner5	1	leon22	10	watson2	0
goerner6	0	leon23	10	watson3	10
goerner7	0	leon3	0	watson4a	10
hettich10c	10	leon4	4	watson4c	10
hettich11	0	leon5	0	watson6	10
hettich2	9	leon6	0	watson7	10
hettich5	10	leon7	0	watson8	10
hettich6	0	leon8	0	watson9	0
hettich7	0	leon9	0	zhou1	10
hettich9	0	li1	0		
honstede1	0	li2	0		

Table 3 - Number of successes using MLOCGAMO

A brief analysis of Table 3 shows that for 52% of the problems more than half of the runs were successful. For problems watson9 and leon21 the solutions obtained had an infeasibility of more than 5×10^{-3}, and, therefore, the runs were considered as unsuccessful. However, the average objective function values found were very close to the solutions known in the literature. For problems lobianco1 and li1, the algorithm obtained very high values for the objective function in all runs. In problem watson13, the algorithm diverged at the first iteration and for the hettich11 problem the algorithm did not converge for any of the runs.

The results presented in Table 4 are the average value of the objective function for solutions with a maximum infeasibility of 5×10^{-3} in the infinite constraints. Again this table reports on problems whose solutions are not available in the literature.

Problem	Average	Problem	Average
gugat1	0.0432	polak2	6.2024
gugat2	0.1620	gugat5b	0.3225
gugat3	0.0000	gugat5c	0.0540
gugat4a	0.0735	gugat5d	43.4083
gugat4b	0.3156	gugat5e	0.0641
gugat4c	0.0623	gugat5f	0.0455
gugat4d	45.6244	gugat6	0.0814
gugat4e	3.3473	gugat7	0.4768
gugat4f	17.0286	hettich1	0.1493
gugat5a	0.0164	hettich10	1.0000
hettich13	-2.2500	hettich12	4.4011
hettich14	-2.1375	powell1	-1.0515
hettich4	1.0000	still1	1.0000
hettich8	0.0183	tanaka1	-0.9999
leon18	-1.7500	userman	0.0000
leon19	0.7969	vaz1	3666.9402
leon24	-9.0771	vaz2	0.0003
lin1	-1.8126	vaz3	6.7194
polak1	5.4456	vaz4	0.0005

Table 4 - Average objective function value, using MLOCGAMO

Comparing the average objective function values reported in Table 2 and Table 4, we obtain the same results for 40% of the problems (when a relative error of 5×10^{-3} is considered).

CONCLUSIONS

We describe a penalty function method for solving SIP problems, where equality and inequality finite constraints are considered, together with a set of inequality infinite constraints. The penalty technique is parameterized by two penalty parameters, and a strategy to update them is also proposed.

The proposed penalty technique is implemented in MATLAB and we have coined it as SiRedAl. The proposed technique addresses, in each external iteration, the computation of all the global (and some local) optima for problems (2). Therefore, the proposed algorithm belongs to the class of reduction type methods for SIP. The multi-local problems were solved by using two available solvers: MLOCPSOAm and MLOCGAMO.

In order to confirm the viability of the implemented algorithm we tested SiRedAl with a test set of 117 test problems. For 79 problems we provide a compare, in terms of successes, to the results reported in the literature. For the remaining problems we report on the objective function obtained.

The numerical results show that the proposed technique presents a moderate success rate. We emphasize that parameter tuning for the addressed problems is not done. When using the MLOCPSOAm, for the multi-local problems, the success rate is higher than when the MLOCGAMO is considered.

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A RECONFIGURATION, OR INTEGRATION, TIME STRUCTURE MODEL FOR ELEMENTARY SEQUENTIAL SYSTEM ARCHITECTURE

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Abstract: A model of reconfiguration, or integration, time structure for elementary sequential system architecture, i.e. for the system integration of two subsystems in sequential relation is presented. The model covers the two most general "groups" of the integration signature architectures: 1) the "traditional", so-called "transactional" integration models, namely the "direct" or "proprietary" architecture, "federated" architecture and "open" architecture, and 2) the emerging "communicational" integration models, namely in its "generative integration" model that is characterized by the integration life-cycle that comprises the phases of "integration synthesis", "integration operation" and "integration termination".

Keywords: Reconfiguration Time, Integration Time, System integration, System Architecture.

1. INTRODUCTION

The requirement for dynamic system reconfiguration is forced by the nowadays growing dynamics and uncertainty of environment as well as by the growing competitiveness and by the emergent requirement for sustainability in such dynamic and uncertain environment.

The fundamental underlying issue of reconfigurability is integration, or disintegration, of resources, which is one of the most difficult problems. The difficulty comes from a number of reasons, such as e.g. the needs to integrate always more modern and newer equipment, technologies and architectures, growing number of heterogeneous economic agents, in combination with the requirements for more and more efficiency and effectiveness of integration.

The history of integration mechanisms development is relatively rich and there is a great number of integration mechanisms, models and principles developed continuously following the technological development. However, much less attention has been given to the integration process itself and its quantitative evaluation.

In this paper it is presented a model of reconfiguration, or integration, time structure for elementary sequential system architecture, i.e. for the system integration of two subsystems in sequential relation, Fig. 1.

The reconfiguration, or integration, time structure model is developed as a general model for the elementary sequential architecture, intended to be "inclusive". It means that the model is constructed in a way to "cover" the "signature" architectures of existing particular architectures used in variety of integration mechanisms of virtually all natures.

In that way, the model covers the following two most general "groups" of the integration signature architectures: 1) the "traditional", so-called "transactional" integration models, namely the "direct" or "proprietary" architecture, "federated" architecture and "open" architecture, Fig. 2, and 2) the emerging "communicational" integration models, namely in its "generative integration" model that is characterized by the integration life-cycle that comprises the phases of "integration synthesis", "integration operation" and "integration termination", Fig. 3.

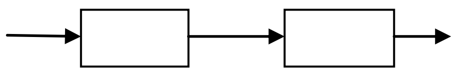


Fig. 1 Elementary sequential system architecture

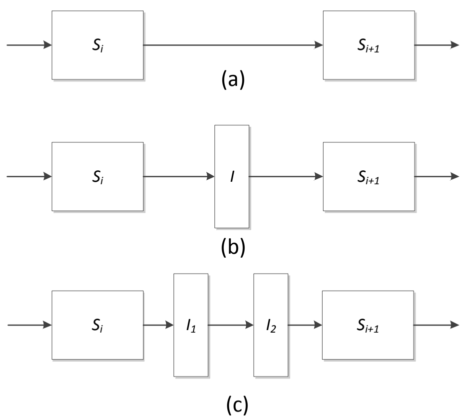


Fig. 2. Three basic integration architectures: (a) Direct (b) Federated (c) Open Architecture [1].

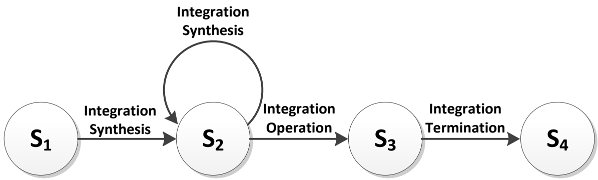


Fig. 3. Generative Integration process life cycle basic model [2] [3].

The model is developed as an analytical model, considering the reconfiguration, or integration, time as a linear structure.

The model could serve a number of particular and concrete integration models by interpretations and instantiation the concrete processes.

For example, the model serves both intra- and inter- organizational integration of resources of different types such as data, applications (software), hardware (computers and industrial and transportation equipment), humans, other organizations, whether these come from within the organization (intra-organizational integration) or these are independent organizations that are necessary to integrate in a supply-chain or a virtual or networked organization (inter-organizational integration).

The following paper's sections present the informal underlying integration process in general (Chapter 2), which serves as a base for further detailing of the model, and in the subsequent section (Chapter 3) the model is presented in a graphical and analytical forms. Finally, the paper closes with the conclusions, recommendations for the future work and conclusions (Chapter 4).

2. A RECONFIGURATION / INTEGRATION, PROCESS AND TIME STRUCTURE

Fig.4 schematizes the initial approach to a reconfiguration, or integration, time structure model for elementary sequential system architecture.

On the highest level the integration time consists of the following phases: the eligible resources identification time, resource negotiation time, resource contract and integration time.

These phases are explicit in the case of inter-organizational integration but also, it is valid, under the correct interpretation, for the intra-organizational integration too. For the case of inter-organizational integration it is in accordance with the independent selection model [4].

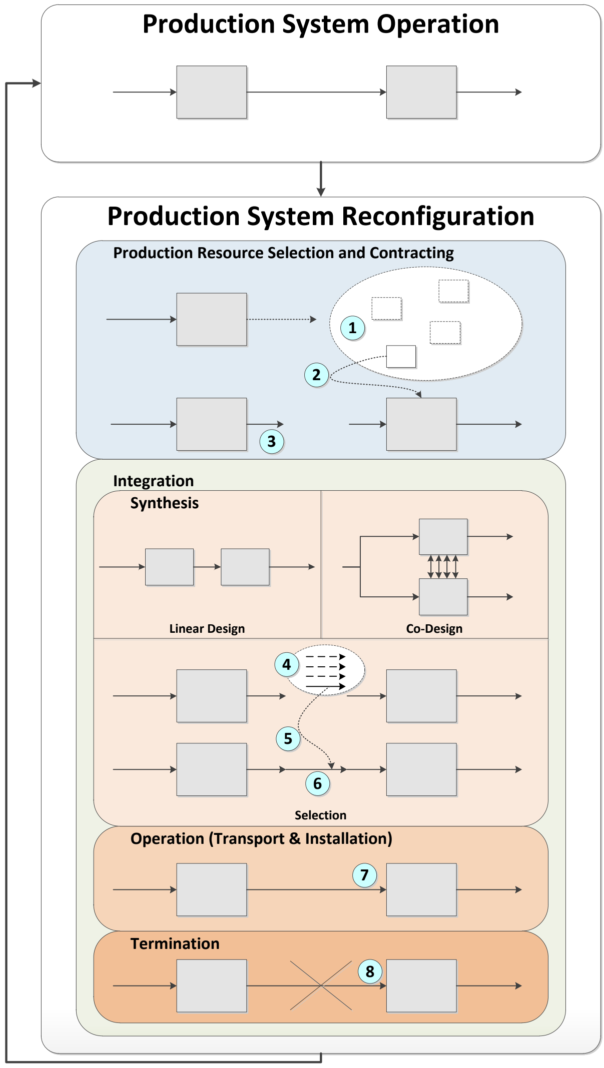


Fig. 4 The initial approach

In Fig. 4 these are represented in the following way: initially the best resource from the Search Domain (of eligible resources) is selected, which is represented by the step 1. Then, the process proceeds with the resource negotiation process, step 2.

Following the independent selection model for inter-organizational integration, the tree types of negotiation are considered [4]. If negotiation is successful, then the process proceeds with contracting (in the case of inter-organizational integration, while this step could be interpreted as acquisition of the resource or resource in the case of intra-organizational integration, or if the resource already exists intra- organization then this step's time is zero), step 3.

The following steps concern the process of integration itself of the contracted (or acquired or existed) resource. It is considered that the integration of resources further proceeds through the three integration life-cycle phases: synthesis, operation and termination [3].

So, the step 4 represents the integration instrument synthesis (design) process. The process of integration mechanism "synthesis" could be one of the three types, which will be denoted as Linear Design, Co-Design or Selection Time.

The "synthesis" in principle means "design" of a new integration mechanism (as it might be inexistent on the "market", or because of lesser costs of design than its acquisition). When design is performed as a "traditional" design methodology it is denoted as Linear design, while when design is performed as a collaborative and/or communicational process (e.g. following the Semiotic framework for Manufacturing Systems Integration and its Generative Integration model, [3] and Fig. 3), it is denoted as Co-Design.

If the "synthesis" would be of the type "selection" of the integration mechanism then it would have, besides the selection (of the integration mechanism) phase itself, two additional phases, i.e. the processes of negotiation and contracting of the integration mechanism, steps 5 and 6 respectively.

Finishing integration instrument synthesis process, the next process is integration mechanism transport and implementation (transport & installation), step 7.

Concerning the step 7, the integration mechanism could be implemented in one of three well-known architectures: Direct Architecture, Federated Architecture and Open Architecture, e.g. see [1] and Fig. 2. Implementation of any of three architectures implies the corresponded time structures.

The last component of the integration time structure is the integration termination process, step 8.

So the production system operation can start and continue until a new reconfiguration is required (return to the step 1).

3. THE TIME STRUCTURE MODEL

In this section the reconfiguration, or integration, time structure model is presented.

In the Fig. 5 model is presented through a structure chart of the reconfiguration, or integration, time components structure, the numbers representing the integration process steps depicted in the Fig. 4.

Further, the model is presented in an analytical form. For the model variables the following notations is used.

Table 1 – Notations used in the structure model

t_{Reconf}	Reconfiguration Time
$t_{RSelection}$	Resource Selection Time
$t_{RSearch}$	Resource Search Time
$t_{RNegotiation}$	Resource Negotiation Time
T_{Aut}	Automatic Negotiation Time
T_A	Auction Negotiation Time
T_{DN}	Direct Negotiation Time
$t_{RContracting}$	Resource Contracting Time
$t_{RIntegration}$	Resource Integration Time
$T_{IISynthesis}$	Integration Instrument Synthesis Time
$T_{IOperation}$	Integration Implementation Operation Time
$t_{ITermination}$	Integration Termination Time
$T_{LDesign}$	Linear (or Sequential) Design Synthesis Time
$T_{CoDesign}$	Co-Design Synthesis Time
$T_{Selection}$	Selection Synthesis Time
t_{Search}	Search Synthesis Time
$t_{Negotiation}$	Negotiation Synthesis Time
$T_{Contrating}$	Contracting Synthesis Time
T_{SameR}	Same Resources Integration Time
$T_{DifferentR}$	Different Resources Integration Time
$T_{DArchitecture}$	Direct Architecture Resources Integration Time
$T_{FArchitecture}$	Federated Architecture Resources Integration Time
$T_{OArchitecture}$	Open Architecture Resources Integration Time
T_{DAPI}	Direct Architecture Physical Implementation Time
T_{FAPI}	Federated Architecture Physical Implementation Time
T_{OAPI}	Open Architecture Physical Implementation Time

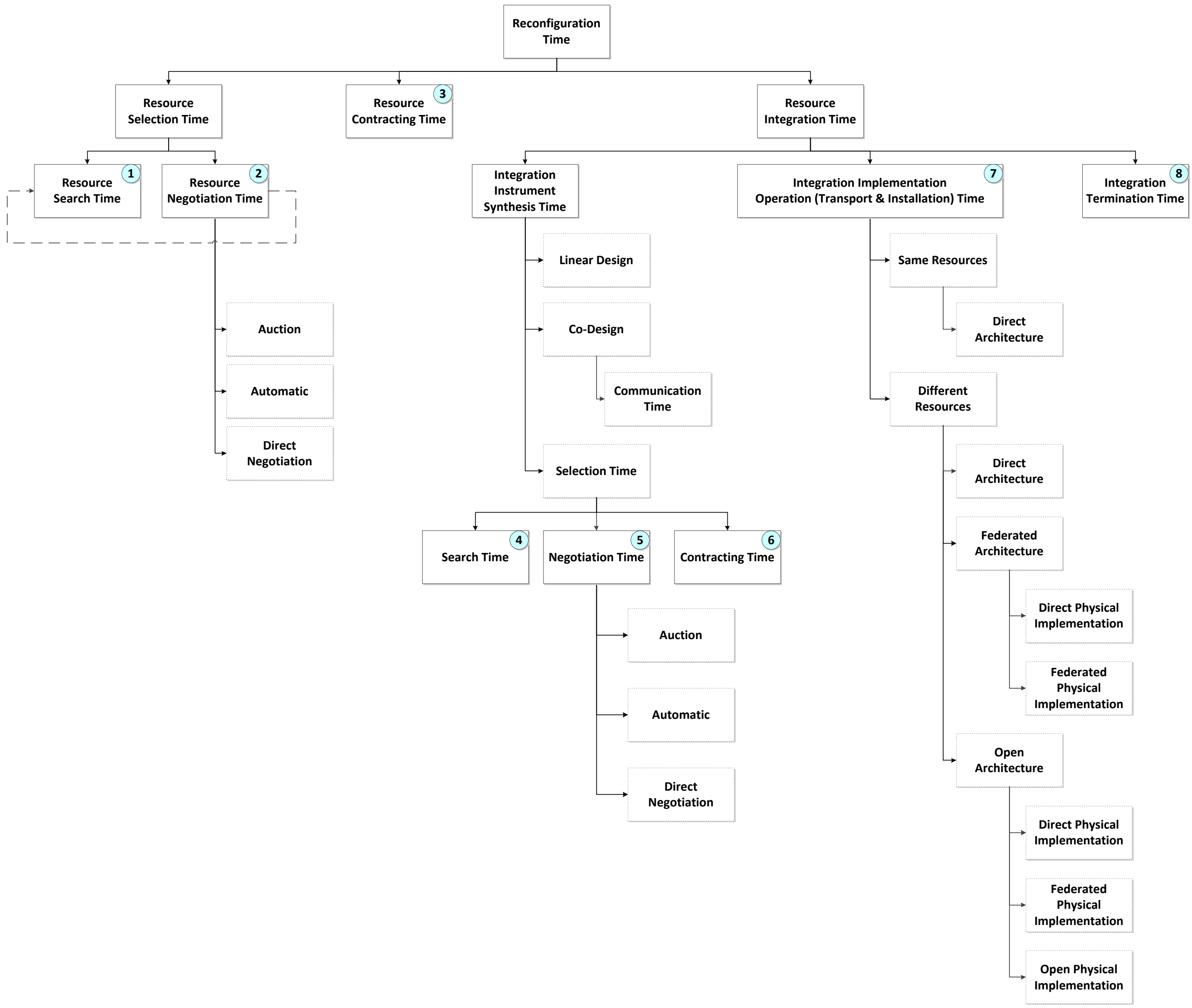


Fig. 5 The reconfiguration, or integration, time components structure chart

Following the chart (Fig. 5) (and [5]) and the notations above-mentioned, the Reconfiguration Time can be decomposed as we can see on the Equation 1.

$$t_{Reconf} = t_{RSelection} + t_{RContracting} + t_{RIntegration} \quad (1)$$

The Resource Selection Time is calculated as the sum between the Resource Search Time and the Resource Negotiation Time (Equation 2).

For the Resource Negotiation Time only one of the Negotiation Time types can occur, i.e., only one type of Negotiation (auction, automatic and direct) can be chosen (this means that the negotiation time has an Exclusive OR (⊕) structure) (Equation 3).

$$t_{RSelection} = t_{RSearch} + t_{RNegotiation} \quad (2)$$

$$T_{RNegotiation} = T_{Aut} \oplus T_A \oplus T_{DN} \quad (3)$$

The Resource Integration Time is composed by the sum between the Integration Instrument Synthesis Time, the Integration Implementation Operation Time and the Integration Termination Time, as we can see in Equation 4.

$$T_{RIntegration} = T_{IISynthesis} + T_{IOperation} + T_{ITermination} \quad (4)$$

Integration Instrument Synthesis Time can occur, like in the Negotiation Time, has an Exclusive OR way (⊕), between the three types of Instruments: Linear (or Sequential) Design, Co-Design and Selection Synthesis Time (Equation 5).

$$T_{IISynthesis} = T_{LDesign} \oplus T_{CoDesign} \oplus T_{Selection} \quad (5)$$

In turn, the Selection Synthesis Time as one Integration Instrument Synthesis is the sum between the Search Synthesis Time, Negotiation Synthesis Time and the Contracting Synthesis Time (Equation 6).

$$T_{Selection} = T_{Search} + T_{Negotiation} + T_{Contrating} \quad (6)$$

The Selection Synthesis has included the Negotiation Synthesis Time (Equation 6). For the Negotiation Synthesis Time such as the Resource Negotiation Time only one of the Negotiation Time types can occur (Equation 7).

$$T_{Negotiation} = T_{Aut} \oplus T_A \oplus T_{DN} \quad (7)$$

Based on the integration architectures, the Integration Implementation Operation Time can only occur between Same Resources or Different Resources, in an Exclusive OR Structure (⊕) (Equation 8).

To the case of Same Resources, the Direct Architecture is associated (Equation 9), and for the Different Resources the Federated Architecture or Open Architecture are associated, in an Exclusive OR Structure (⊕) (Equation 10).

$$T_{IOperation} = T_{SameR} \oplus T_{DifferentR} \quad (8)$$

$$T_{SameR} = T_{DArchitecture} \quad (9)$$

$$T_{DifferentR} = T_{DArchitecture} \oplus T_{FArchitecture} \oplus T_{OArchitecture} \quad (10)$$

As we can see in Fig. 5 the time structure is different for different physical implementations. It should be noted that although the system can have one logical integration architecture type, the real, physical Integration Time could be reduced to a different Integration Architecture type and the consequent integration time. For example, in the case of need to integrate two different types of systems in open architecture if the integration mechanism I_1 is embedded in the first system the integration architecture is reduced to the federated architecture and the physical implementation time is calculated as for the federated architecture (Fig. 6).

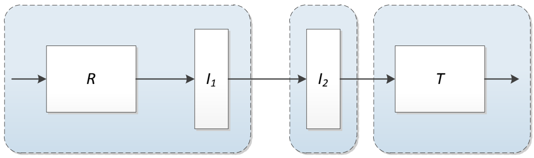


Fig. 6. Reduction of a logical Open Architecture to a physical Federated Architecture

For that reason the Integration Implementation Operation Time is calculated as (Equation 11):

$$T_{IOperation} = \sum_{i=1}^{nreconf} t_i \, , i = 1, \ldots, nreconf \quad (11)$$

where t_i is the integration type implementation operation time in each reconfiguration i. This time (t_i) depends on architecture integration type j for each integration node between resources (Equation 12). So:

$$t_i = T_{SameR_i} * y_{i1} + \sum_{j=1}^{3} T_{DifferentR_{ij}} * y_{ij} \quad (12)$$

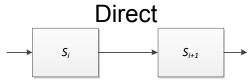
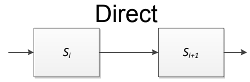
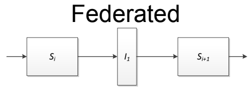
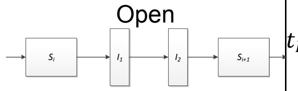
where y_{ij} is binary variable to identify if the architecture type j occur in reconfiguration i (Equation 13):

$$y_{ij} = \begin{cases} 1 \\ 0 \end{cases} \quad (13)$$

$$j = \{1,2,3\} = \{Direct, Federated, Open\}$$

In Table 2 an integration implementation operation time between S_i and S_{i+1} for same and different resources in each reconfiguration i is presented.

Table 2 – Integration Operation Time for each architecture type.

Architecture	Integration Operation Time
Same Resources	
Direct 	$t_{IgR_{i1}} = t_{IOper_{S_i,S_{i+1}}}$
Different Resources	
Direct 	$t_{DifR_{i1}} = t_{IOper_{S_i,S_{i+1}}}$
Federated 	$t_{DifR_{i2}} = t_{IOper_{S_i,I_1}} + t_{IOper_{I_1,S_{i+1}}}$
Open 	$t_{DifR_{i3}} = t_{IOper_{S_i,I_1}} + t_{IOper_{I_2,S_{i+1}}}$

4. CONCLUSIONS

The model presented is applicable to virtually any integration architecture or mechanism for intra- or inter- organizational reconfiguration and/or integration under the appropriate interpretation. However, the model is developed only for the linear, or sequential, structure (architecture) of a system. This is because the linear structures are virtually basic structures for developing more complex architectures as well as the linear structures could serve as a starting model for developing reconfiguration and integration time models for other architectures, such as shown on the Fig. 7, i.e. for the parallel, feedback, and hierarchical configuration ([1])

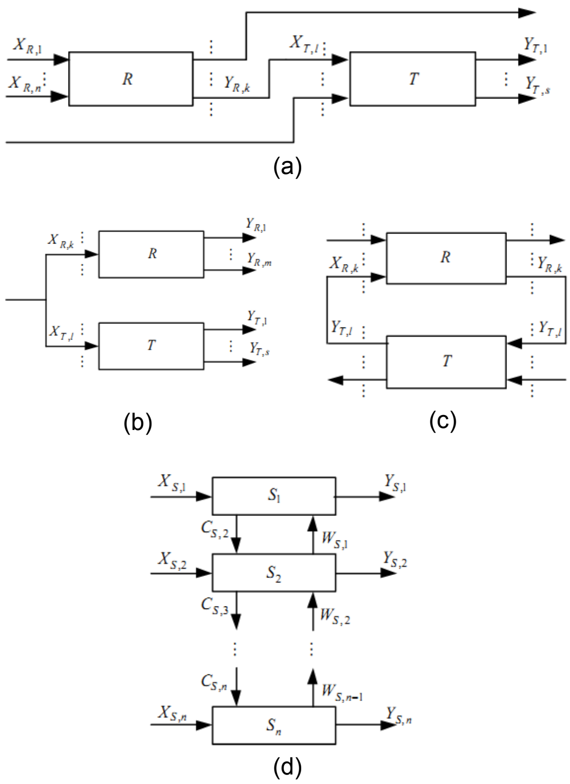


Fig. 7. Types of process, or systems, relations: (a) serial, (b) parallel, (c) feedback, (d) hierarchical configuration ([1])

The future work should consider (1) the further development of the model for more complex structure that would imply other types of relationship among the systems to be reconfigured and/or integrated and (2) the model validation over the existing integration technologies, architectures and mechanisms as well as in real-life scenarios.

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RELAXATION INDUCED METHODS BASED ON COLUMN GENERATION FOR VEHICLE ROUTING PROBLEMS

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Abstract: We address an hybrid method for the vehicle routing problem that combines column generation, branch-and-bound and relaxation based heuristics. In particular, we combine the hybrid linear programming based algorithm proposed by Hanafi and Wilbaut [3] for mixed integer programming problems with branch-and-price. The heuristics proposed in [3] are convergent. They consist of solving iteratively the linear relaxation of the problem, and in deriving lower and upper bounds. The linear relaxation model within the proposed exact algorithm corresponds to the well-known column generation model. Preliminary computational results are reported.

Keywords: Heuristics; Techniques and tools for industrial engineering; Transportation systems; Decision support systems.

INTRODUCTION

In this paper, we address the resolution of the vehicle routing problem (VRP) through hybrid procedures that combine column generation, branch-and-bound and relaxation based heuristics. We propose an exact Branch-and-Price (B&P) algorithm that integrates the column generation technique with the hybrid linear programming based algorithm proposed by Hanafi and Wilbaut [3] for the 0-1 mixed integer programming problems.

The VRP is a combinatorial optimization problem whose application area is very wide. It is of major practical relevance for every activity that implies any kind of route design, whether we are talking about a transportation system where there is a fleet of vehicles to manage (public transports, courier services, transportation of materials, distribution services) or of less intuitive fields as robotics or microprocessors. It is well known that the transportation costs represent a large percentage of the total logistics costs, and the great growth in the number of software packages concerning the VRP, available in the market, illustrates the fact that industries understand the economical savings that come with a more efficient use of their resources. A more efficient planning of routes may also translate into environmental, social and energy benefits. Therefore, and not surprisingly, this is one of the most studied problems in the Operations Research field.

We consider a variant of the VRP where there is a single depot o, an homogeneous fleet of K vehicles with a capacity of W units, and a set of customers represented by N={1,…n}. Each customer i has a given load li to be collected. It is not mandatory to visit all customers, but there is a minimum amount of load to be collected at each planning period. The optimization objective is to minimize the total cost of the vehicle routes.

NETWORK FLOW MODEL

This problem can be formulated as a network flow model with binary variables x_{ij}^k representing a vehicle *k* passing or not through a given arc (*i,j*). It is defined in a graph *G=(V,A)*, where *V=N∪{o}* represents the set of nodes in the graph and *A* the set of its oriented arcs. Each arc (*i,j*)∈*A* has a cost c_{ij}, which represents the distance between *i* and *j*. This model can be stated as follows:

$$\min \sum_{k=1}^{K} \sum_{(i,j)\in A} c_{ij} x_{ij}^k \qquad (1)$$

$$\sum_{k=1}^{K}\sum_{j\in V} x_{ij}^{k} = 1, \qquad \forall i \in N, \tag{2}$$

$$\sum_{k=1}^{K}\sum_{j\in N} x_{o,j}^{k} \le K, \tag{3}$$

$$\sum_{j\in V} x_{o,j}^{k} = 1, \qquad k = 1,\dots,K, \tag{4}$$

$$\sum_{j\in V} x_{ij}^{k} - \sum_{j\in V} x_{ji}^{k} = 0, \quad k = 1,\dots,K,\ \forall i \in N, \tag{5}$$

$$\sum_{i\in V} x_{i,o}^{k} = 1, \qquad k = 1,\dots,K, \tag{6}$$

$$Q_i^k + l_i - Q_j^k \le \left(1 - x_{ij}^k\right)W, k = 1,\dots,K, \quad \forall (i,j) \in A, \tag{7}$$

$$l_i \le Q_i^k \le W, k = 1,\dots,K, \forall i \in N, \tag{8}$$

$$x_{ij}^k \in \{0,1\}, k = 1,\dots,K, \forall (i,j) \in A. \tag{9}$$

The visit to all customers is enforced by constraints (2). The limit on the maximum number of vehicles is defined by constraint (3). Constraints (4)-(6) are flow conservation constraints. The capacity constraints are defined by (7) and (8). The general integer variables Q_i^k represent the amount of waste collected by vehicle *k* when it arrives at customer *i*. The objective function (1) minimizes the total cost of the vehicle routes.

COLUMN GENERATION AND BRANCH-AND-PRICE ALGORITHM

We propose an exact branch-and-price algorithm to solve the integer problem. The column generation model (a flow model over paths) is a Dantzig-Wolfe decomposition of a network flow model over arcs, whose variables are also used in our branching scheme.

Master Problem

Let β denote the set of all feasible routes. The master problem can be formulated as follows:

$$min \sum_{p\in\beta} c_p \rho_p \tag{10}$$

s.t.

$$\sum_{p\in\beta} a_{ip}\rho_p = 1, \forall i \in N, \tag{11}$$

$$\sum_{p\in\beta} \rho_p = K, \tag{12}$$

$$\rho_p \in \{0,1\}, \forall p \in \beta. \tag{13}$$

Variables ρ_p represent flows over paths. They are binary variables (13), as the same path will never be used more than once. The cost of a path $p \in \beta$, which is equal to the sum of the arc costs that define it, is denoted by c_p. Coefficients a_{ip} define whether customer $i \in N$ is visited ($a_{ip} = 1$) or not ($a_{ip} = 0$) in path *p*. Constraints (11) ensure that the customers are visited. Constraint (12) limits the number of used routes. Model (10)-(13) is a set-partitioning model.

Pricing Subproblem

The pricing subproblem consists of K shortest path problems with capacity constraints. Since we are considering a homogeneous fleet of vehicles, these K problems are identical and thus only one shortest path problem is solved. The paths should be acyclic. However, in routing problems under resource constraints, this constraint is usually ignored in the linear programming relaxation. Generally, the bound provided by the relaxed problem is weaker, however the corresponding subproblems are easier to solve. Although the relaxed problem remains NP-hard, it can be solved efficiently using pseudo-polynomial algorithms. The pricing subproblem can be formulated as follows:

$$min \sum_{(i,j)\in A} c'_{ij}\varphi_{ij} \tag{14}$$

s.t.

$$\sum_{j\in V} \varphi_{o,j} = 1, \tag{15}$$

$$\sum_{i\in V} \varphi_{ij} - \sum_{i\in V} \varphi_{ji} = 0, \forall j \in V, \tag{16}$$

$$\sum_{j\in V} \varphi_{j,o} = 1, \tag{17}$$

$$Q_i + l_i - Q_j \le \left(1 - \varphi_{ij}\right)W, \forall (i,j) \in A, \tag{18}$$

$$l_i \le Q_i \le W, \qquad \forall i \in N, \tag{19}$$

$$\varphi_{ij} \in \{0,1\}, \qquad \forall (i,j) \in A. \tag{20}$$

In column generation, the objective of the subproblem is to price the columns that are not explicitly considered in the restricted master problem (RMP). In model (14)-(20), the objective function (14) minimizes the total reduced cost of a path (columns in the RMP) by taking into account the individual contribution of each arc to that cost.

Let π_i, $i \in N$, and θ be the dual variables associated to constraints (11) and (12) of the master, respectively. The reduced cost c'_p of a path $p \in \beta$ is given by the following expression:

$$c'_p = c_p - \sum_{i \in N} a_{ip}\pi_i - \theta.$$

In our implementation, this pricing subproblem was solved with a dynamic programming algorithm.

Branch-and-Price Algorithm

To search for the optimal integer solution, we resort to branch-and-bound. When column generation is applied at each node of the branching tree, this method is called branch-and-price (B&P). Branching on the variables of the master problem should not be done. Forcing a column to be equal to 1 is trivial (we just have to remove the clients visited in the corresponding route and update other values at the right hand side of the constraints), but trying to exclude a column from the RMP is much more complicated. What happens is that the forbidden column will be regenerated if nothing is done to avoid it. The only way to avoid regeneration is to reformulate the pricing subproblem. That usually leads to very complicated subproblems. In our implementation, we considered branching on the variables x_{ij} of the network flow model. If the solution of a linear relaxation is fractional, two branching nodes are created with the following branching constraints: $x_{ij} = 1$ and $x_{ij} = 0$. These constraints are easily enforced in the RMP. For that purpose, we have to keep the definition of the paths related to each column in the RMP.

ITERATIVE LINEAR PROGRAMMING-BASED HEURISTIC (ILPH)

In [3], Hanafi and Wilbaut described an improved version of an algorithm proposed in [1] to solve the 0-1 multidimensional knapsack problem. They also proved the finite convergence of this heuristic and refer that it can be used to solve general 0-1 mixed integer problems. It consists of iteratively solving the LP-relaxation of the problem, obtaining a lower bound, and of solving a related reduced problem that provides an upper bound. A reduced problem consists of the original problem with some fixed variables. The fixed variables are the ones whose value in the previous LP-relaxation solution was equal to 0 or 1. At each iteration, a new constraint is added to the LP-relaxation, so that a different reduced problem is generated at each iteration. This new constraint is called a pseudo-cut. Let $J = \{1, \dots, n\}$ be the index set of binary variables of the problem considered, the pseudo-cut is defined as:

$$\sum_{j \in J^0(\bar{x})} x_j + \sum_{j \in J^1(\bar{x})} (1 - x_j) \geq 1, \tag{21}$$

where $\bar{x}$ is an optimal solution of the LP-relaxation, $J^1(\bar{x}) = \{j \in J: \bar{x}_j = 1\}$ and $J^0(\bar{x}) = \{j \in J: \bar{x}_j = 0\}$.

INTEGRATING THE ITERATIVE LINEAR PROGRAMMING-BASED HEURISTIC (ILPH) WITH COLUMN GENERATION

Our proposed algorithm consists of applying Algorithm 1 (ILPH) described in [3] to our problem, using the column generation technique. Our approach can be generally described as:

1. Solving the LP-relaxation of the problem with column generation.
2. Transforming the variables of the previous model into variables of the network flow model over arcs in order to generate a pseudo-cut, as described in (21).
3. Solving the reduced problem with our branch-and-price algorithm.
4. Add the generated pseudo-cut to the current restricted master problem and goto to step 1, until the stopping criterion is satisfied.

The reason to transform the original variables into arc variables (step 2) is related to the pricing subproblem. More precisely, each new constraint added to the master problem induces a cost that must be added to the dual cost of each arc in the subproblem. That is why the coefficients of the pseudo-cuts must be associated to arcs, as we do not keep track of a complete path in the pricing subproblem. The reduced problem is obtained from the original problem by setting to 0 or 1 the arcs variables whose flow in the optimal solution of the previous LP-relaxation is, respectively, 0 or 1. This can be done simply by changing the distances matrix. The integer problem is then solved with our B&P algorithm [4]. Note that we may always need to generate new columns. As mentioned in [3], most of the time of the algorithm is used to solve the reduced problems. Therefore, we implemented Algorithm 2 - Iterative Linear Programming-based Heuristic with dominance [3] that significantly reduces the number of integer problems to be solved. It generally consists of solving m LP-relaxations in a first phase, and in a second phase only solving the reduced problems that are non-dominated, according to some derived dominance rules.

Problems with symmetry

The problem of symmetry arises whenever there are two columns in the master problem that correspond to inverse paths. Let us consider a path p and its inverse path p', i.e., the path that visits the same set of customers in the exact inverse order. These two paths are, in practice, the same, as they have the same cost, the same load and visit the same set of customers. However, as the coefficients of the pseudo-cuts are associated to arcs, the columns associated to these two paths become different, allowing the pricing subproblem to generate a column associated to p´ when there is already a column associated to p. This happens because, for each generated pseudo-cut, the columns corresponding to paths p and p' have different coefficients, as p and p' are composed by different arcs. This becomes a problem because a pseudo-cut that eliminates a given solution does not eliminate equivalent solutions composed by inverse paths. This can create a lot of entropy in the convergence of the method. In order to reduce some of the symmetry, at each iteration of the ILPH we generate not only one but several pseudo-cuts. Let ρ_i be the variable associated to column i of the RMP. The cuts generated at each iteration are the following:

1. the original pseudo-cut
2. a pseudo-cut that corresponds to a solution with all the inverse paths selected in the original solution
3. a pseudo-cut that represents a solution where all columns *i* such that $\rho_i = 1$ are replaced by a combination of column *i* and column *i'*, the latter corresponding to the inverse path of the first, such that $\rho_i = \rho_{i'} = 0.5$
4. a set of pseudo-cuts, one for each column *i* such that $\rho_i = 1$, which represent a solution with $\rho_i = \rho_{i'} = 0.5$

Example 1

Let us consider an instance with 15 customers. Suppose that for a given iteration of the LP-relaxation, the restricted master problem has eleven columns, corresponding to eleven paths, i.e., sequences of visited customers. Assume that the paths $p_s, \forall s \in \{1,\dots,11\}$, corresponding to each of the columns, represent the following sequences of visited customers: p1 = (1), p2 = (2), p3 = (3,12,3), p4 = (4,10,4), p5 = (5,12,5), p6 = (6,12,6), p7 = (6,5), p8 = (5,1), p9 = (6,1), p10 = (6,3) and p11 = (6,2). Suppose that the optimal solution is the following: $\rho_2 = 1$, $\rho_4 = 0.5$, $\rho_8 = 1$, $\rho_{10} = 1$ and $\rho_i = 0$, $\forall i \in \{1,3,5,6,7,9,11\}$. In this first iteration, six pseudo-cuts are added to the model, each one corresponding to a different (but in practice identical) solution, according to the points 1 to 4 described above. Let $\rho_{i'}$ be the variable that corresponds to the column related to the inverse path represented in column i. The considered six solutions would be the following:

Solution 1	Solution 2
$\rho_2 = 1$ $\rho_4 = 0.5$ $\rho_8 = 1$ $\rho_{10} = 1$	$\rho_{2'} = 1$ $\rho_{4'} = 0.5$ $\rho_{8'} = 1$ $\rho_{10'} = 1$
Solution 3	**Solution 4**
$\rho_2 = 0.5$, $\rho_{2'} = 0.5$ $\rho_4 = 0.5$ $\rho_8 = 0.5$, $\rho_{8'} = 0.5$ $\rho_{10} = 0.5$, $\rho_{10'} = 0.5$	$\rho_2 = 0.5$, $\rho_{2'} = 0.5$ $\rho_4 = 0.5$ $\rho_8 = 1$ $\rho_{10} = 1$
Solution 5	**Solution 6**
$\rho_{2'} = 1$ $\rho_{4'} = 0.5$ $\rho_8 = 0.5$, $\rho_{8'} = 0.5$ $\rho_{10'} = 1$	$\rho_2 = 1$ $\rho_4 = 0.5$ $\rho_8 = 1$ $\rho_{10} = 0.5$, $\rho_{10'} = 0.5$

Table 1: Six identical solutions from example 1

The six new pseudo-cuts would therefore be:

$$0\rho_1 + 2\rho_2 - 2\rho_3 + 0\rho_4 - 2\rho_5 - 2\rho_6 - 1\rho_7 + 3\rho_8 + 1\rho_9 + 3\rho_{10} + 1\rho_{11} \leq 7$$

$$0\rho_1 + 2\rho_2 - 2\rho_3 + 0\rho_4 - 2\rho_5 - 2\rho_6 - 1\rho_7 - 3\rho_8 - 3\rho_9 - 3\rho_{10} - 1\rho_{11} \leq 7$$

$$0\rho_1 + 0\rho_2 - 2\rho_3 - 4\rho_4 - 2\rho_5 - 2\rho_6 - 1\rho_7 + 0\rho_8 - 1\rho_9 + 0\rho_{10} - 1\rho_{11} \leq -1$$

$$0\rho_1 + 2\rho_2 - 2\rho_3 + 0\rho_4 - 2\rho_5 - 2\rho_6 - 1\rho_7 + 3\rho_8 + 1\rho_9 + 3\rho_{10} + 1\rho_{11} \leq 7$$

$$0\rho_1 + 2\rho_2 - 2\rho_3 + 0\rho_4 - 2\rho_5 - 2\rho_6 + 0\rho_7 + 0\rho_8 + 0\rho_9 + 3\rho_{10} + 1\rho_{11} \leq 4$$

$$0\rho_1 + 2\rho_2 - 2\rho_3 + 0\rho_4 - 2\rho_5 - 2\rho_6 - 2\rho_7 + 3\rho_8 + 0\rho_9 + 0\rho_{10} + 0\rho_{11} \leq 4$$

COMPUTATIONAL RESULTS

We conducted some preliminary computational experiments on a set of random instances with 15 and 25 customers. We only performed steps 1, 2 and 4 of our proposed algorithm. With these experiments we intend to assess the convergence of the lower bounds of the algorithm. Column nCust provides the number of customers of the instance, and zLR and zIP correspond to the linear relaxation and optimal integer solution, respectively. The values in column zIP were previously determined with the algorithm described in [4]. Column nIter provides the number of iterations of the algorithm that are necessary to achieve a solution value that is greater than or equal to the optimal integer one (zIP). At each iteration, the linear relaxation with the current set of generated cuts is solved.

Name	nCust	zLR	zIP	nIter
Inst_15_1	15	2606.00	2688	44
Inst_15_2	15	4610.00	4887	224
Inst_15_4	15	6626.50	6727	199
Inst_15_5	15	5395.00	5395	1
Inst_15_6	15	2518.50	2673	149
Inst_15_7	15	1487.65	1796	115
Inst_15_8	15	3598.35	3993	864
Inst_15_9	15	2214.80	2307	90
Inst_15_10	15	5867.79	5961	203
Inst_15_11	15	5559.33	5747	131
Inst_15_12	15	2952.33	3096	74
Inst_15_13	15	2224.00	2276	19
Inst_15_14	15	4145.50	4169	25
Inst_15_15	15	5038.50	5272	418
Inst_25_2	25	741.00	741	1
Inst_25_4	25	805.83	873	76
Inst_25_5	25	2018.24	2136	292
Inst_25_8	25	6351.50	6474	222
Inst_25_12	25	4018.15	4063	284
Inst_25_14	25	6167.00	6167	1

Table 2: Lower bounds convergence

Considering this set of instances, it takes in average 172 iterations for the lower bounds to converge to the optimal solution.

CONCLUSIONS

In this paper we propose a new hybrid procedure that combines a B&P algorithm with the ILPH described in [3], to solve exactly the capacitated vehicle routing problem. The combination of the two techniques in the described iterative method causes a considerable increase of symmetry. This symmetry is significantly reduced with the introduction of several pseudo-cuts at each iteration. We conducted some preliminary computational experiments on a set of randomly generated instances in order to test the convergence of its lower bound.

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ON THE CHARACTERISATION OF UNCERTAINTY IN PERFORMANCE MEASUREMENT SYSTEMS

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INTRODUCTION

Performance measurement systems (PMSs) are receiving increasing attention from academics and practitioners particularly after the development of the Balanced Scorecard (BSC) [1], and many PMSs are available nowadays [2]. Nevertheless, this subject is not new and, for example, quality gurus such as Crosby, Feigenbaum, or Deming recognized the importance of performance measurement as an activity within quality management. Recently, there are many publications on the design of PMSs, (developed for industries, services, SMEs, public services, non-for profit organizations) and about their implementation and use, however there is a lack of investigation on the uncertainty measurement of such performance measures (PMs)

The PMS purpose is to contribute to both the goals and the sustainability of the organisation [3]. This contribution is the result of actions taken given the values of PMs, however, when measuring the same parameter using the same device and method, a variation in the reading will be apparent due to inaccuracies inherent in the measurement system. This variation and other types of inaccuracies or uncertainty are present in physical systems and it should be reflected in the PMS. Furthermore, there are many measurement capability studies of “hard” variables, but there are few attempts to deal with attribute data and “soft” PMs (based on subjective assessment), such as customer satisfaction.

Failure to deal with such uncertainty will result in simplified models that could lead to worse decisions.

The first contribution of this work is to provide a general classification of sources of uncertainty that could affect PMs. This would allow the establishment of a common theoretical framework to classify uncertainty in the field of Performance Measurement. Secondly, it would provide a basis for practitioners to provide evidence about the uncertainty of existing PMSs.

The hypothesis is that organisations need to reflect the uncertainty of its systems and contextual factors in their PMs to improve their models. This identification of uncertainty in PMS is the first step to reduce such uncertainty. This work is part of ongoing research, which is being carried out on world-class organisations and subsequently will do longitudinal case studies to ascertain their applicability.

Methodology

The research methodology to characterise PMs’ uncertainty will comprise both deductive and inductive stages. It starts with a literature review on the field of performance measurement, quality management and uncertainty to develop through deductive logic a conceptual and theoretical structure about the classification of uncertainty in PMs. This paper presents the findings of this deductive research which will later be tested through case studies, to allow another step of inductive research to support, change or refute the proposed characteristics of the performance measure (PM).

LITERATURE REVIEW

Background on TQM and Business Excellence

There is a plethora of quality improvement paradigms to help organisations improve their products or services [4]. Overall, Business Excellence is replacing the narrow objective of meeting customer specifications; the focus is on the performance of the whole system, and not just the outputs.

Based on quality management principles such as the ones of ISO 9000 series of standards and quality awards, one common element emerges:

the process approach. It emphasises on the need to measure critical variables and to quantify process effectiveness and efficiency.

Prajogo and Sohal [5] argue that TQM will remain an essential part of developing and maintaining a competitive advantage for organisations. Excellence models and quality awards have highlighted the importance of performance measurement in achieving Business Excellence.

Scholarly academic research strives to conceptually and empirically extract the components of quality management and their linkages to performance, such as the BSC [1], the performance prism [6] and Kanji's Business Excellence Model [7].

Performance measurement systems

Juran and Godfrey [8] argue that "the choice of what to measure and the analysis, synthesis, and presentation of the information are just as important as the act of measurement itself" and emphasise the system to which the measurement process belongs. The measurement process consists of steps needed to collect data and present results. The larger measurement systems also embrace the decisions that are made and the framework in which the process operates.

A thorough understanding of the existing measurement systems, formal and informal, spoken and unspoken, as they are perceived [9] must be achieved, i.e. the overall framework in which the PMS operates should be understood [8].

According to Macpherson [10] there are two approaches to identifying PMs: top-down and bottom-up. Using the first approach, the search for PMs is based on the mission and vision of the organisation. The latter, on the other hand, is determined by what data is currently available and has the advantage of being cost effective by only focusing on visible data [10]. A third approach [11] is outside (or customer) - inside (or internal processes), endorsing the argument about the importance of looking at the organisation from the customer's viewpoint [12].

Critical Success factors of PMS

To contribute to the planning phase of the PMS, critical success factors (CSF) about data quality are identified in the literature. PMs should be [10, 13, 14, 15]: Relevant (C1); Credible (C2); Precise (C3); Valid (C4); Reliable (C5); and Frequent (C6).

Other CSFs are discussed in the performance measurement literature are:

- Data collection and methods for calculating the PMs must be clearly defined [16] (C7);
- Presentation of PMs must be simple [12] (C8);
- PMs must be flexible [14], including being tied to desired results [15] (C9);
- More extensive use should be made of subjective data [13] (C10);
- Ratio-based performance criteria are preferred to absolute numbers [16] (C11).

Several frameworks have been proposed to develop and use PMSs in organisations [17], a sample of which will be summarised in the next section.

Performance Measurement Frameworks

There are two basic types of PM in any organisation – those related to results, and those that focus on the determinants of the results [9]. This suggests that it should be possible to build a performance measurement framework (PMF) around the concepts of results and determinants. The EFQM model also supports this concept.

Perhaps the best know PMF is Kaplan and Norton's BSC [1, 9]; it seems to be the most influential and dominant concept in the field. The authors of the BSC suggested [18] the definition of strategy maps to describe the cause-and-effect relationships between the identified measures, but according to Wilcox and Bourne [19] these relationships are outdated. The collaborative culture of the integrated supply chain has triggered the emergence of new measures [20].

Kanji and Sá [21] started with the BSC and integrated TQM principles and CSFs resulting in a model which focussed on measuring how an organisation is performing from an outside perspective. Bititci et al. [17] developed a model for an integrated and dynamic PMS. As the previous framework it should have: an external and internal monitoring system. Basu [20] also argued that the PMs should be more externally focused for the total network and a formal senior management review process with two-way communication to all partners was essential to success.

Integrative approaches to performance evaluation, including auditing, self-assessments, benchmarking and performance measurements are still required [21]. Self-assessment against quality award models has gained prominence in areas where quality audits were lacking, most importantly in performance improvement [20, 21].

The Performance Prism' authors [6] refer to the importance of identifying stakeholders' contributions, as they are part of a reciprocal relationship with the organisation. They also argue that it is necessary to start to think about measurement as the process of gathering management intelligence.

UNCERTAINTY OF PERFORMANCE MEASURES

Characterising uncertainty

Any measurement is subject to imperfections; some of these are due to random effects. Repeated measurements will show variation because of such random effects.

When uncertainty is evaluated and reported in a specified way it indicates the level of confidence that the value actually lies within the range defined by the uncertainty interval.

"The definition of uncertainty (of measurement) is a parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand" [22]:2. Thus the uncertainty, in metrology, is a quantitative indication of the quality of the result. It gives an answer to the question, how well does the result represent the value of the quantity being measured? It allows users of the result to assess its reliability, for example for the purposes of comparing results from different sources or with reference values. Confidence in the comparability of results can help to reduce barriers to trade.

Uncertainty is a consequence of unknown random and systematic effects and is therefore expressed as a quantity, i.e., an interval about the result.

"When reporting the result of a measurement of a physical quantity, it is obligatory that some quantitative indication of the quality of the result be given so that those who use it can assess its reliability. Without such an indication, measurement results cannot be compared, either among themselves or with reference values given in a specification or standard. It is therefore necessary that there be a readily implemented, easily understood, and generally accepted procedure for characterizing the quality of a result of a measurement, that is, for evaluating and expressing its uncertainty." [22]:viii. This is common knowledge in metrology but it is not being applied in ordinary PMs. Thus the quality of a result can be expressed through the uncertainty associated with such PM.

According to ISO 2003 [23], section 7.3, the measurement uncertainty shall be estimated for each measurement process covered by the measurement management system and all known sources of measurement variability shall be documented. If these requirements are to be applied in all PMs of the organization there would be the need to identify all sources of variability. However, few works [24, 25, 26, and 27] report the inclusion of such variability in their studies.

There is a wide variety of reasons why uncertainty is present in PMSs. Particularly, to reliability studies Coolen [28] presents three main reasons: (i) in many reliability applications, there may be few, if any, statistical data available, implying stronger dependence on subjective information in the form of expert judgments; (ii) the relaxation of dependence on precise statistical models justified by physical arguments; (iii) an assumption underlying most mathematical work in the study of system reliability is that the exact system structure and dependence relations between components are known, which may well be unrealistic in many applications for all but the simplest systems.

These relationships are conditioned by the system's environment and may generate contradictory information, vagueness, ambiguity data, randomness, etc. In reliability studies, the vagueness of the data have many different sources: it might be caused by subjective and imprecise perceptions of failures by a user, by imprecise records of reliability data, by imprecise records of the tools appropriate for modeling vague data, and suitable statistical methodology to handle these data as well [29].

Both [24] and [25] considered uncertainty in manufacturing systems and argue that reducing it is a means to improve the system. Other studies have included uncertainty in project scheduling [27], inventory control [26], or supply chain management [30].

Specific components of PMS's uncertainty and its classification, to facilitate systematic studies, are not known.

Methods to deal with uncertainty of PMs

Traditionally, uncertain parameters in inventory control and supply chain management problems have been treated as stochastic processes and described by probability distributions [30]. A probability distribution is usually derived from evidence recorded in the past [26]. This requires a valid hypothesis that evidence collected are complete and unbiased, and that the stochastic mechanism generating the data recorded continues in force on an unchanged basis [30]. However, there are situations where all these requirements are not satisfied and, therefore, the conventional probabilistic reasoning methods are not appropriate [30]. In this case, uncertain parameters can be specified based on the experience and managerial subjective judgment. Often, an expert may feel that a given parameter is within a certain range and may even have an intuitive feel for the best value within that range [26].

It may be convenient to express these uncertainties using various imprecise linguistic expressions [30]. Fuzzy sets are found to be useful in representing these approximate qualifiers, due to their conceptual and computational simplicity. The typical membership functions that can represent fuzzy customer demand, fuzzy external supplier reliability and the fuzzy lead time [30]. They can be derived from subjective manager belie.

To deal with uncertainty in scheduling environment 3 other approaches (apart from stochastic and fuzzy) are presented: reactive, proactive and sensitivity analysis [27], while [25] argue that for complex processes, methodologies based on artificial intelligence and simulation should be used.

On production planning, a need for further research is identified [25]:

- development of new models that contain additional sources and types of uncertainty, such as supply lead times, transport times, quality uncertainty, failure of production system and changes to product structure, etc.
- investigation of incorporating all uncertainty in an integrated manner;
- development of empirical works that compare the different modelling approaches with real case studies.

Lee et al. [31] propose a fuzzy AHP approach to assign weights to BSC perspectives, while [32] used the same approach to calculate the weights of questionnaire criteria, Hu et al. [33] applied it to determine the relative weightings of four risk factors, while [34] used it to obtain weights in multicriteria multifacility location problems.

The costs incurred by organisations to manage uncertainty should not be ignored, and different methods to deal with uncertainty have different requirements and associated costs. In risk management a parallel situation can be established because identified risks are not all subject to the same detailed subsequent treatment, for example qualitative methods for risk assessment (less expensive than quantitative methods), may be enough for lower level risks, while quantitative techniques would be economically reasonable for higher level risks. Similarly, methods to deal with uncertainty have associated costs, and if some components of uncertainty, are small compared to others, it could be unjustifiable to make a detailed determination of all its components. This idea is also expressed in ISO 10012 (section 7.3.1).

Nunes and Sousa [35] studied some instances of the propagation of uncertainty in PMSs and its effects in the decision criterion, which also contains uncertainty. This will not be the focus of this paper.

Having reviewed performance measurement systems and uncertainty, the next section will address the classification of PMs' uncertainty.

UNCERTAINTY COMPONENTS OF PM

Components of uncertainty can be classified according to the following three categories: Measurement process; Data collection; and PM.

Measurement process

The uncertainty associated with the measurement process can be introduced by: the measurement method and the tools and/or criteria (when assessment is made by human perceptions) used to carry out assessment. Therefore in this category, the next components of uncertainty can be distinguished.

UC_MM – Measurement method uncertainty component

This uncertainty is related with errors in the method used to perform the measurement. The procedure to perform the measurement may be wrongly defined or may not be clear, originating misinterpretation. Wrong measurement methods can also be introduced by the measurement performer.

Examples of UC_MM:

- Errors in measuring setup time due to bad misinterpretation of a procedure may lead to inconsistent data;
- Productivity indicator may be affected by defective products or parts, rework and work-in-process, if they are considered in the number of good units.

UC_PA - Precision and accuracy of measurement tool

Precision is how Repeatable and Reproducible the measurement is. This is what is calculated during a gage R&R study. Accuracy, also referred to as "bias", is how close the data is to the "real" value. Usually, accuracy is assured by the calibration of the measurement tool.

UC_H - Human uncertainty component

Frequently, in turbulent systems, the available information is scarce, which implies stronger dependence on subjective information in the form of expert judgement. According to CSF C10, more extensive use should be made of subjective data [13], but if the measurement system relies on human judgement, it can be assumed that some uncertainty will result. The existence of several methods (AHP, Delphi technique, etc.) to overcome such ambiguity supports this component.

Examples of UC_H:

- In quality control one person identifies defects. If that person is replaced by another the classification may differ;
- The Risk Priority Number calculated in FMEA methodology is based on three subjective indicators.

Data Collection

In the process of data collection to subsequently calculate a PM, error can be introduced due to human failure or to the data collection system (software).

UC_DC – Data collection (equipment/ operator) uncertainty component

This component includes errors in the introduction of data in database, a bad calibration of an automated data acquisition system, the absence of data whose release was planned.

Examples of UC_DC:

- Assigning a defect to a wrong product;
- The maintenance technician registers the beginning of the corrective maintenance task, but forgets to register the end of the action.

Performance Measure

Uncertainty may be introduced by the selected PM which may not adequately represent the reality to be measured. The difference between what is measured and what it is intended to be measured may be present originally, when the PM is firstly defined, or may appear due to changes in the environment. For PMs or indicators calculated based on other PMs, uncertainty in the PM of high level may be originated by the propagation of uncertainty present in the PMs of low level.

Therefore, in the of PM category, three uncertainty components are identified, as presented below.

UC_D - Definition / Measurand uncertainty component

PM are often tied to desired results (C9) and its presentation must be simple (C8), this may lead to provide a simpler definition of what is to be measured while the reality is more complex.

PMs, to be understandable, should be related to shop floor operations and product and service characteristics (C8 – understandable variables). Their construction should be bottom-up which would make them more cost-effective. However, to be simple and tied to desired results (C8 and C9) they should derive from strategy (top-down), or from customer's requirements. These alternatives mean that any given solution has to increase uncertainty to comply with these requirements.

Examples of UC_D:

- The detection of different defects if added can ignore differences between them, showing to top management a simplistic view of the organisation;
- The assessment of customer satisfaction implies that the definition of customer is clear.

UC_E - Environmental uncertainty component

Uncertainty can increase if some environment characteristics change, particularly if System Complexity increases. CSF C7 requires that methods for calculating the PMs must be clearly defined, but any environmental change (maintenance policy, layout, or weather conditions) could cause a revision in data collection methods. Changes in PMs are to be simple, but the system may not. Stakeholders' needs may change and the relationships between variables will also vary.

Examples of UC_E:

- Changes in the procedure of verifying incoming parts in warehouses, excluding defects' detection, may cause defective parts to be considered as good once it is supposed that this inspection is done;
- Introduction of a new product, different from an existing one, could cause variation in the PM "percentage of defective units" (C11 – Ratio based PM can no longer make sense if different products are added).

UC_A – Aggregating uncertainty component

When two or more PMs are combined to generate one new PM (performance indicator - PI) the uncertainties of each PM will affect the uncertainty of the PI.

The formula to calculate a PI or weights of different PMs, may not be general over time (for example if the range of products changes beyond its initial state).

An assumption underlying most performance measurement studies is that the structure of the system and the dependence relations between parts are known. These limitations constitute an important source of uncertainty that is visible when one tries to select the models (strategy maps) that represent the input/output relation of PMs.

An additional source of uncertainty comes from the imperfect knowledge about the interdependency relationships among the parameters and variables. These relationships are conditioned by the system's environment and may generate contradictory information, ambiguity or randomness fuzziness.

Examples of UC_A:

- There are 2 similar products assessed to infer about its field performance. The average performance (PI) of the products will be the average of their individual performances. Now let us assume Product 1 and 2 are assessed each in 3 critical variables and there is a new product more complex that is assessed in 6 critical variables. The aggregated PI may not represent this situation.
- The method of calculation of one PM is based on another but the defined formula was not the result of a generalised consensus between stakeholders.

UNCERTAINTY QUALITATIVE ASSESSMENT

As referred previously, quantitative methods usually require more resources and data than qualitative ones.

The first step to characterise uncertainty would be to identify what Uncertainty Components are associated with each PM.

The second would be to classify the uncertainty level of each Uncertainty Component. Given that, even in structured systems (such as automotive manufacturing plants) risk assessment and FMEAs use, typically, a Likert scale with 10 item. The authors propose a scale with only 3 levels (the minimum would be 2 levels) but similar solutions with other levels are also feasible.

For example, a scale for UC_A component could be:

No Uncertainty – There is a recognized formula that derives from theory and is not scientifically questioned.

Some uncertainty – An agreed formula is accepted by all stakeholders.

High uncertainty – The formula was defined without consensus and may be changed.

After building similar scales to each uncertainty component, a matrix could relate each PM with each uncertainty component. This matrix would be a tool to decide which uncertainty components would be further studied, and could provide evidence to change existing PMs. The uncertainty reduction of the PMS would provide less risk in decision making.

CONCLUSION AND FUTURE RESEARCH

This work provides a classification of uncertainty components that affect the quality of PMs. Can each uncertainty component be decomposed into a systematic and random part? This decomposition will allow the identification of causes that, if changed, could reduce uncertainty.

Case studies will be performed to ascertain the validity of these concepts.

The development of methods to propagate the uncertainty of the PMs throughout the PMS and through different hierarchic levels is being pursued by the authors in another research project.

This work will be extended to deal not only with the uncertainty in the PMS but also with the uncertainty of the decision criteria.

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A LOCATION PROBLEM IN THE FIELD OF WIND ENERGY

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Abstract In the last years, the concerns with the planet sustainability have increased substantially with the changes faced in society. The strong dependence of the modern society on fossil fuels is clear, and it has justified the governmental efforts to reduce the emissions of gases. In this context, the renewable energies, and especially the wind energy, have been a good alternative since they are typically both inexhaustible and clean.

This paper presents new results concerning a problem that arises in the planning of wind farms, namely the location of meteorological masts. The meteorological masts are installed for the measurement of the wind conditions. They are used to perform a specific set of tests. The optimal location of these masts allows the maximization of the dominant wind exposure and the minimization of the number of disturbed sectors. The SADLEMPE decision support system has been developed recently to address this problem. Here, we present new results provided by this application for a real case study.

Keywords: Decision support systems; Energy; Facilities location; Methodology.

INTRODUCTION

Over the years, the society has given special attention to environmental issues and in particular to the consequences of the burning of fossil fuels. The governments developed and implemented policies to decrease the undesirable effects of this source of energy. They invest massively in the sector of the renewable energies, and put a special emphasis on the development of the wind energy. Indeed, because of its cleanness and reliability, wind energy is seen as a good solution to fight against climate change.

The industry based on the power of the wind relies on a mature technology. However, for a wind energy project to be successful, it is important to have a good knowledge of the wind conditions that exist in the site where the turbines are to be located. The conditions of the wind are measured with meteorological masts. The best location of the meteorological masts allows improving the exposure in the directions of the dominant winds, and minimizing the number of disturbed sectors in different periods, namely in the measurement phase, and during the tests of the turbines.

Site calibration

Portugal is an example of a country where a high percentage of the terrain is uneven. According to the guidelines of the standard IEC 61400-12-1 [1], the measurement of the power of the wind in such terrains requires a site calibration before the test. A site calibration quantifies and reduces potentially the effects of the terrain and obstacles on the power performance measurement. Indeed, the terrain and the obstacles may cause a difference in wind speeds. The result of this procedure is to provide a set of correction factors for the wind directions.

Site calibration procedure requires two meteorological masts. One of these masts is installed temporarily. It allows simulating the wind turbine. The other meteorological mast, which is commonly called the reference station, is installed definitively. According to the IEC standard, the location of the reference mast must be between 2 and 4 times the diameter of the rotor of the wind turbine that is being tested. Usually the best distance is set to 2.5 times the diameter of the rotor.

Scope of the paper

The accurate and efficient measurement of the wind conditions call for new methods and tools. This paper describes some of the aspects and outputs of a model-based decision support system (*SADLEMPE - Sistema de Apoio à Decisão para Instalação de Estações Meteorológicas em Parques Eólicos*) developed recently to address this problem. One of the key objective of this application is to provide optimal location points for the meteorological masts within a given wind farm. The application takes into account the distinct functions of the meteorological masts, namely the site calibration function (with a short duration in a predetermined period of the year), and the continuous follow-up of the wind farm.

SADLEMPE relies on an integer programming model that provides the optimal position for the masts together with a hierarchical list of alternative locations. To the best of our knowledge, this application is the first to provide a quantitative approach for the selection and location of meteorological masts by taking into account some fundamental factors such as the dominant wind exposure and the number of disturbed sectors.

METHODOLOGY

For the sake of clearness, we will first introduce the elements of the methodology followed in the development of SADLEMPE. To select the available areas for the installation of meteorological masts, we resorted to a Geographical Information System (GIS), and we followed the standard IEC 61400-12-1 and other technical constrains that apply. The characterization of the wind resource in these areas is the second step of our methodology. For this purpose, we resorted to the methods described in the European Wind Atlas [2]. The information that was collected is related to each potential position for the installation of a meteorological mast. This information comprises for example the characteristics of the wind at undisturbed sectors at medium and long term periods. Furthermore, we collected information concerning the exact coordinates (x_i, y_i) of each candidate position i, the density of candidate points, and information about turbines that are near to a given coordinate in the wind farm. This information is computed in the third step of our methodology using Visual Basic routines. All this data is used later to define the integer programming model. The model is described in detail in [3, 4].

The SADLEMPE decision support system relies on different applications for processing all this information. For the selection of the available areas, it resorts to the application ArcGIS 10.0 [5], that allows the access and management of geographical information. The characteristics of the wind resource are computed in grids of 15 meters using the application WAsP. Finally, we used the IBM ILOG CPLEX optimizer to solve the integer programming model of SADLEMPE [6].

COLLECTING GEOGRAPHICAL INFORMATION

As mentioned above, one of the strong components of our methodology is related to the use of a geographical information system. The functionality of these applications includes the possibility of selecting the available areas, and visualizing important information such as the distribution of the wind occurrences at these available areas.

Selection of the available areas

The identification of the interesting and non-interesting areas is a fundamental issue within our decision support system. To select these areas, one must know a priori the following information:

- the layout of the wind farm;
- the presence of electrical power lines;
- the digital elevation model;
- the environmental constraints;
- the technical constraints related to the masts;
- the requisites defined in the IEC standard.

Figure 1 illustrates a potential area that obeys to one of the technical constraints that apply in our problem, namely the distance between 2 and 4 rotor diameters of the wind turbines.

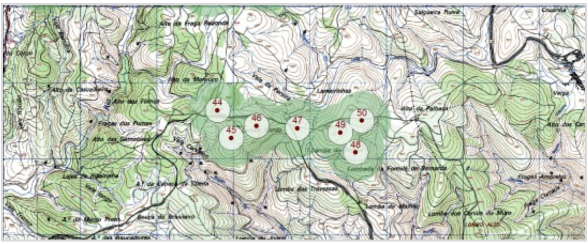

Fig. 1. Definition of an available area according to the IEC 61400-12-1 Standard

The application of other filters such as the limits of the terrain and the need to ensure that the terrain slope is less that 25% yields even more restricted areas, as it can be seen in Figure 2 (in grey).

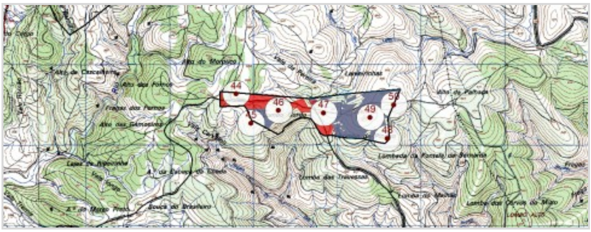

Fig. 2. Available area for the installation of meteorological masts.

GIS Representations

The routines developed in Visual Basic allowed, among other applications, to link the wind occurrences at the allowable measurements sectors for each available location and for each time period considered in this work (test or calibration period and follow-up or long term period). The results of these routines are illustrated in Figure 3 and 5.

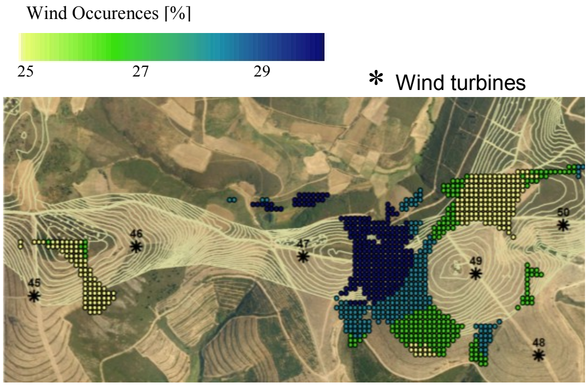

Fig. 3. Wind occurrences for the long term period represented on the GIS software

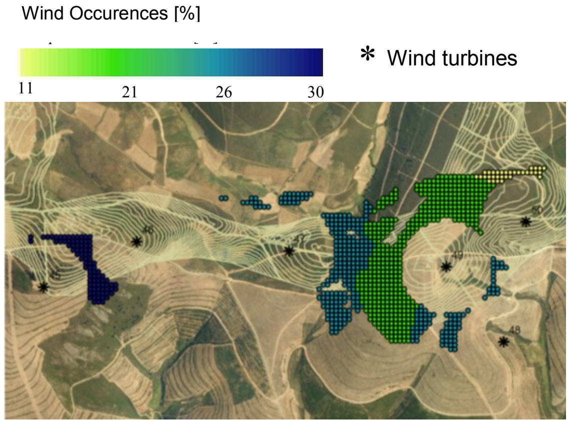

Fig. 4. Wind occurrences for the calibration period represented on GIS software

Furthermore, it is possible to visualize the distance between the available locations and the wind turbines using the GIS application, as illustrated in Figure 5.

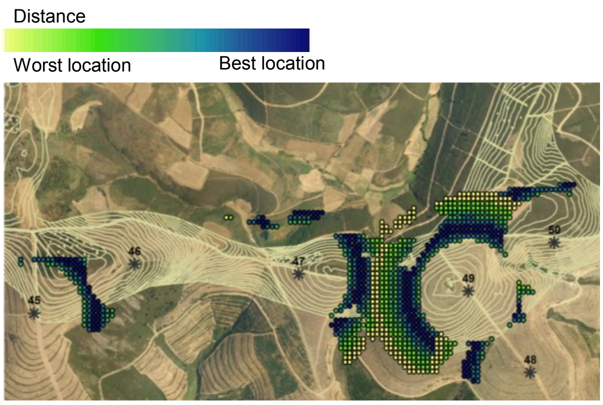

Fig. 5. Representation of the distance between available points and wind turbines

Through the observation of the Figure 5, it is possible to say that the points represented on dark blue are the best locations, because they are close to the ideal distance defined on standard IEC, *ie* 2.5 rotor diameters between the wind turbine and the meteorological mast.

COMPUTATIONAL EXPERIMENTS

In these experiments, we focused on a real case study, namely the case of the wind farm of Alto da Coutada which is located in northern Portugal. The farm is composed by 50 wind turbines with a nominal capacity of 2 MW.

The optimization model embedded into SADLEMPE was analysed from different point of views using as a basis the optimal locations given by the model. In [3, 4], we reported on the experiments performed with SADLEMPE for a given area of a real wind farm. In these experiments, our objective was to compare the solutions provided by the model with the solutions given in a business-as-usual context. Here, we report on the results obtained from the sensitivity analysis conducted on the parameters of the model, with more incidence on the coefficients of the objective function. First, we recall the elements of this function which states as follows

$$max \sum_{i\in I} \left(\gamma(OE1_i + OE2_i)x_i + \beta(OA_i)x_i\right) - \alpha \sum_{i\in I} \left(\frac{\left((dist1_i + dist2_i) - n_{TurbinasPorPonto_i} * D\right) x_i}{D} \right)$$

The coefficients $OE1_i$ and $OE2_i$ stands for the wind occurrences during the calibration period for the first and for second turbine, respectively. The coefficients OA_i are related to the wind occurrences during the long term period. This function considers also the distance between the first wind turbine and the meteorological mast ($dist1_i$), and the second wind turbine and the meteorological mast ($dist2_i$). The coefficient D represents the diameter of a rotor. In all these coefficients, the index i indicates the position that is considered from a list of potential points. Finally, the decision variables represent the selection or not of the position with the index i.

In Table 1, we report on a first set of results obtained with different sets of parameters.

Selection of a meteorological station for calibration of the two wind turbines														
	Factors		Point [ED50 UTM29,m] ID	M	P	WT1	Dist 1	Dist1 /DR	WT2	Dist2	Dist2 /DR	Occ. Calib. 1	Occ. Calib. 2	Occ. long term	r
Analyze 1	α	100	514	623088	4598435	45	198.6	2.4	46	199.6	2.4	31.0	22.0	26.5	3438.6
	γ	1													
	β	1													
	λ	6													
	δ	6													
	d(m)	205													
	r	2000													
Analyze 2	α	1	491	623133	4598420	45	218.3	2.7	46	165.6	2.0	31.2	22.4	27.0	2312
	γ	100													
	β	1													
	λ	6													
	δ	6													
	d (m)	205													
	r	2000													
Analyze 3	α	1	433	624078	4598375	49	316.2	3.9	47	243.5	3.0	24.4	27.9	30.4	4443.0
	γ	1													
	β	100													
	λ	6													
	δ	6													
	d(m)	205													
	r	2000													

Table 1. Sensitivity analysis: results of the first set of experiments

In Table 1, column *ID* identifies the candidate point, while columns *M* and *P* identifies the corresponding coordinates. Columns *WT1* and *WT2* correspond respectively to the identifications of the first and the second turbine that can be calibrated from this point, while *Dist1* and *Dist2* show the distances between the point and each one of the turbines. The table indicates also the wind occurrences during the calibration period for the first wind turbine (*Occ. Calib. 1*) and for the second wind turbine (*Occ. Calib. 2*) . The wind occurrences during to the long term period are shown in column *Occ. Long term*. Finally, the density of points is given in the last column.

The coefficients δ and λ are used in the constraints of the model to ensure respectively that the deviation between the occurrences during the calibration period and the long term period do not exceed a pre-defined value, and that the deviation between wind occurrences when two turbines are to be calibrated is not above a given limit.

In the first case depicted in Table 1, the coefficient α was set to 100. The objective was to penalize the positions that are far from the regular 2.5 times the diameter of the rotors. Not surprisingly, the model returned a position for the meteorological mast that is at a distance of 2.4 times the diameter of the rotors. In the second test, we increased the value of the coefficient γ, which applies to the wind occurrences observed during the calibration period. The distance to the turbine decreased but still remains within the valid interval. The number of occurrences also increased marginally compared to the results of the first test. Finally, our third experiment was done with the intent of favouring the positions with high wind occurrences during the long term period. We set the coefficient β to 100. The long term occurrences increased naturally, but at the same time we noticed a marginal reduction of the total value of the short term occurrences related to the calibration period.

In our second set of experiments, we varied the coefficients α, β and γ and of the model. The corresponding results are given in Table 2.

Selection of a meteorological station for calibration of the two wind turbines														
	Factors		Point [ED50 UTM29,m] ID	M	P	WT1	Dist 1	Dist1 /DR	WT2	Dist2	Dist2 /DR	Occ. Calib. 1	Occ. Calib. 2	Occ. long term	r
Analyze 4	α	1	501	624138	4598420	49	265.2	3.2	47	302.5	3.7	23.9	27.5	29.6	4166.1
	γ	1													
	β	100													
	λ	4													
	δ	4													
	d(m)	205													
	r	2000													
Analyze 5	α	1	501	624138	4598420	49	265.2	3.2	47	302.5	3.7	23.9	27.5	29.6	4166
	γ	100													
	β	1													
	λ	4													
	δ	4													
	d (m)	205													
	r	2000													
Analyze 6	α	100	85	624393	4598150	48	211.9	2.6	49	197	2.4	26.5	21.9	27.9	2746.8
	γ	1													
	β	1													
	λ	4													
	δ	4													
	d(m)	205													
	r	2000													

Table 2. Sensitivity analysis: results of the second set of experiments

For this set of experiments, we changed, now the values of δ and λ to 4, while in the previous experiments these coefficients were set to 6. This minor variation related to the wind occurrences provides different optimal solutions. This is important to avoid large differences in wind occurrences of different periods.

Figure 6 shows the localization of the optimal solutions obtained in the previous experiments.

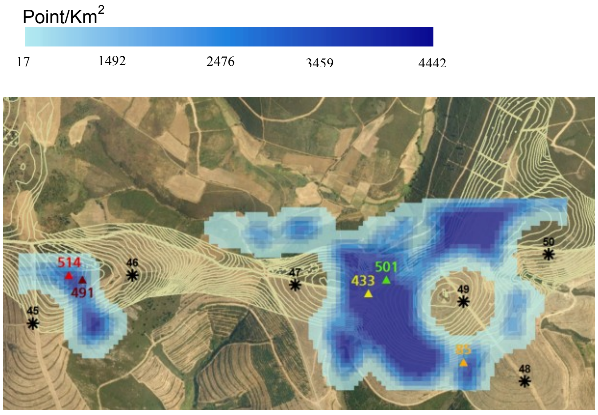

Fig. 6. Optimal localization points from the sensitivity analysis experiments

In the figure, the dark blue areas represent the regions where the density of possible localizations is higher. They can be used as an indicator of neighboring alternative localizations around each positions. Choosing points in these areas is positive since it increases the chances of finding a good alternative if the selected localization is considered not to be feasible during a field visit.

CONCLUSION

The model used to solve the practical location problem considered in this paper was effective in identifying good quality locations for the meteorological stations. The locations provided by the model are those that maximize the number of wind occurrences from undisturbed sectors, during the calibration period and the long term period.

The choice of a particular location is a direct consequence of the parameters used in the objective function. Indeed, the comparison between the results of the sensitivity analysis shows a variation of the optimal solution that depends clearly on the weights of the different factors present in the objective function. Despite the variations, the locations resulting from the application of SADLEMPE tend to outperform the solutions proposed by humans for the optimization criteria that were considered.

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AN EXACT SOLUTION APPROACH FOR A MULTI-FOLLOWER BILEVEL OPTIMIZATION PROBLEM

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Abstract: Bilevel problems are hierarchical optimization problems in which the set of feasible solutions is determined by the set of optimal solutions of a parametric problem. These problems model hierarchical decision processes involving a leader that takes his decision by considering the reaction of a follower. In this paper, we address a bilevel optimization problem with multiple followers, and we explore an exact solution approach that is an extension of an algorithm proposed recently for the case where there is only one follower. The algorithm consists in two phases. The first phase is based on dynamic programming rules, while the second consists in solving the reformulated problem that results from the first phase. This reformulated problem is solved using a commercial solver. Computational results are reported at the end of the paper.

Keywords: Analytical methods; Numerical methods; Decision support systems; Operations planning.

INTRODUCTION

Bilevel optimization problems were first described by Bracken and McGill in [1]. These problems are related to the well-known Stackelberg game [2], which consists in a hierarchical decision process where a special player (the so-called leader) takes his decision by knowing the choices of the other players (the followers). The leader forces the decisions of the followers with his own decision, and chooses the best option by solving the Stackelberg game.

In this paper, we address a class of bilevel optimization problems characterized by the presence of multiple followers. This problem can be formulated as follows:

$$\max_{x,y} f(x,y) = \sum_{i=1}^{s}\sum_{j=1}^{n_i} d_{ij}x_{ij}$$

$$s.t.$$

$$\sum_{i=1}^{s} y_i \le b, \quad y_i \in IN,$$

$$\max_{x} g^i(x) = \sum_{j=1}^{n_i} c_{ij}x_{ij}, \quad i = 1,...,s,$$

$$s.t.$$

$$\sum_{j=1}^{n_i} a_{ij}x_{ij} \le y_i, \quad i = 1,...,s,$$

$$x_{ij} \in \{0,1\}, \quad i = 1,...,s, \quad j = 1,..,n_i .$$

From this point forward, we will use the acronym BLPMF to refer to this problem. The vectors a_i, d_i and c_i are of dimension n_i, with i = 1,..,s, and s denoting the number of followers. We will assume that the coefficients of these vectors and the coefficient b are positive integers. The vector of variables x (respectively y) represents the variables related to the followers (respectively the leader). The function $f(x,y)$ (resp. functions $g^i(y)$ for i = 1,…,s) corresponds to the objective of the leader (respectively the followers).

Problem BLPMF applies to many different practical situations. As an example, consider the case of a transportation company that owns a single vehicle. The problem of the company consists in assigning space inside this vehicle to each one of its clients. The goods that the clients want to dispatch are stored in containers. The space assigned to a client i is associated to the variable y_i of the previous model. The constraint $\sum_{i=1}^{s} y_i \le b$ indicates that the sum of all the space assigned to the clients cannot exceed the capacity of the vehicle. The variables x_{ij} are equal to 1 if the j^{th} container of client i is selected and placed in the vehicle, and 0 otherwise. The constraints $\sum_{j=1}^{n_i} a_{ij} x_{ij} \le y_i$ make sure that the total weight of the selected containers of client i (one of the followers) do not exceed the space (with maximum weight y_i) reserved for this client i by the company (the leader). The value n_i represents the number of containers of the client i. Each container j of a client i has a profit c_{ij} associated to the client, and a profit d_{ij} associated to the company. The value c_{ij} may represent the importance of the container j for the client i, while d_{ij} represents the transportation price for this container j that the client i has to pay to the company. As explained before concerning the bilevel interaction, the leader should fix his variables y_i and each follower i has to optimize its profit respecting this decision. Then, the leader decision has to generate the best reaction of followers.

Bilevel optimization problems have been explored in depth both from a theoretical and a practical point of view [3]. The complexity of these problems comes from the fact that they are generally non-convex and non-differentiable. Indeed, even the linear programming relaxation of these problems is NP-hard [4,5]. Different methods have been proposed in the literature for linear bilevel problems with or without integer variables [6, 7]. For the bilevel problem with a continuous leader variables and binary variables for the followers, for example, different approaches were proposed in [8, 9 , 10].

In this paper, we explore a particular class of bilevel problems with multiple followers, and with binary variables in the follower problems. We propose an exact algorithm that is an extension of an approach that was proposed recently in [10] for the problem with a single follower. The approach consists in two phases. In the first phase, a set of dynamic programming rules are applied. The second phase consists in solving the reformulated problem (a multidimensional knapsack problem). using a commercial solver.

The paper is organized as follows. We start by describing the decomposition that we used to solve the global problem, and the elements of the dynamic programming approach. Then, the reformulated problem is introduced. The quality of the algorithm is evaluated through a set of computational experiments. In the last section, some conclusions are drawn, and suggestions for future research are given.

SOLUTION ALGORITHM FOR THE BLPMF

Before we present the dynamic programming rules used in this paper, we describe first a decomposition of the problem. This decomposition will help us to solve a series of bilevel optimization problems with only one follower. This decomposition was proposed originally in [8]. The BLPMF can be written as follows:

$$
\begin{aligned}
&\max_{x,y} f(x,y) = \sum_{i=1}^{s} f^i(x,y) \\
&s.t. \\
&\sum_{i=1}^{s} y_i \le b, \\
&(sub_1)\begin{cases} f^1(x_1,y_1) = d_1 x_1 \\ s.t. \\ \quad y_1 \le b,\ y_1 \in IN, \\ \quad \max_x g^1(x) = c_1 x_1 \\ \quad s.t. \\ \quad\quad a_1 x_1 \le y_1, \\ \quad\quad x_1 \in \{0,1\}^{n_1} \end{cases} \\
&\quad . \\
&\quad . \\
&\quad . \\
&(sub_s)\begin{cases} f^s(x_s,y_s) = d_s x_s \\ s.t. \\ \quad y_s \le b,\ y_s \text{ integers} \\ \quad \max_x g^s(x) = c_s x_s \\ \quad s.t. \\ \quad\quad a_s x_s \le y_s \\ \quad\quad x_s \in \{0,1\}^{n_s} \end{cases}
\end{aligned}
$$

Any feasible solution (x, y) ($x = (x_1, x_2,..., x_s)$ and $y = (y_1, y_2,..., y_s)$) for the problem BLPMF should be feasible for each sub-problem and for the leader constraint. In other words, (x, y) is feasible for BLPMF if each sub-solution (x_i, y_i) (for i = 1,…, s) is feasible for the sub-problem (sub_i) and $\sum_{i=1}^{s} y_i \le b$. To find an optimal solution, we need to find the best combination of all possible feasible sub-solutions of all the sub-problems. Before defining how these combinations are made (phase two of the algorithm), we will describe first the dynamic programming rules that are applied to each sub-problem sub_i in order to eliminate all the dominated sub-solutions.

Dynamic Programming for the 0-1 Problem

In the literature, the sub-problems solved in this stage are called Bilevel Knapsack Problems (BKP). These problems state as follows.

$$(sub_i)\begin{cases} \underset{(x,y)}{Max}\, f^i(x,y) = \sum_{j=1}^{n_i} d_{ij}x_{ij} \\ \quad s.t. \\ \quad\quad y_i \le b, \quad y_i \in IN, \\ \quad\quad \underset{x}{Max}\, g^i(x) = \sum_{j=1}^{n_i} c_{ij}x_{ij} \\ \quad\quad\quad s.t. \\ \quad\quad\quad\quad \sum_{j=1}^{n_i} a_{ij}x_{ij} \le y_i, \\ \quad\quad\quad\quad x_{ij} \in \{0,1\}, \quad j = 1,\ldots,n_i. \end{cases}$$

In this section, we describe the dynamic programming rules for solving exactly the previous problems sub_i. These rules were proposed first in [10]. These rules are applied on the variables of the follower considering simultaneously the objective functions of the follower and the leader. The algorithm is pseudo-polynomial with a complexity of $O(n_i b)$. It can solve both the optimistic and pessimistic cases [11]. Here, we will only refer to the optimistic case.

The dynamic programming process is composed by two phases. The first one (the forward phase) consists in computing the set of non-dominated solutions, while the second one (backtracking phase) consists in determining the optimal solutions. The forward and backtracking phases of the dynamic algorithm are described in more detail below.

Forward Phase

Two tables are generated in this phase: one for the optimal follower values $g_k^i(\beta)$ and another for the optimal leader values $f_k^i(\beta)$ associated with the sub-problems. We have that

$$g_k^i(\beta) = \max\left\{\sum_{j=1}^{k} c_{ij}x_{ij} : \sum_{j=1}^{k} a_{ij}x_{ij} \le \beta, x_i \in \{0,1\}^k\right\},$$

and

$$f_k^i(\beta) = \max\left\{\sum_{j=1}^{k} d_{ij}x_{ij} : x \in Arg\max g_k^i(\beta)\right\}$$

with $\beta \in [0,b]$ being an integer.

The procedure for the forward phase is given below.

for k = 2 to n_i do

for β = 0 to b do

if $\beta < a_{ik}$ then

$g_k^i(\beta) = g_{k-1}^i(\beta)$ *and* $f_k^i(\beta) = f_{k-1}^i(\beta)$

end if

if $\beta \ge a_{ik}$ then

$$g_k^i(\beta) = \max\left(g_{k-1}^i(\beta), g_{k-1}^i(\beta - a_{ik}) + c_{ik}\right) \quad (1)$$

if $g_{k-1}^i(\beta) \ne g_{k-1}^i(\beta - a_{ik}) + c_{ik}$ then

$$f_k^i(\beta) = \begin{cases} f_{k-1}^i(\beta), \text{if } g_k^i(\beta) = g_{k-1}^i(\beta), \\ f_{k-1}^i(\beta - a_{ik}) + d_{ik}, \text{if } g_k^i(\beta) = g_{k-1}^i(\beta - a_{ik}) + c_{ik} \end{cases} \quad (2)$$

end if

if $g_{k-1}^i(\beta) = g_{k-1}^i(\beta - a_{ik}) + c_{ik}$ then

$$f_k^i(\beta) = \max\left(f_{k-1}^i(\beta), f_{k-1}^i(\beta - a_{ik}) + d_{ik}\right) \text{ (Opt.)} \quad (3)$$

end if

end if

end for

end for

Initially, only one item xi1 is considered, and hence the optimal values for the leader and for the follower for each value β are as follows:

$$g_1^i(\beta) = \begin{cases} 0 \text{ for } \beta = 0,..,a_{i1} - 1 \\ c_{i1} \text{ for } \beta = a_{i1},...,b \end{cases}$$

$$f_1^i(\beta) = \begin{cases} 0 \text{ for } \beta = 0,..,a_{i1} - 1 \\ d_{i1} \text{ for } \beta = a_{i1},...,b \end{cases}$$

When *k>1*, the table of the follower is generated at step (1). The cardinality of the follower optimal solution set is used to generate the table for the leader. In the first case, if there is only one optimal solution for the follower problem, then the leader updates his value according to (2). In the second case, if several equivalent solutions exist for the follower, then the leader objective function is updated according to (3) (in the optimistic case). Note that if $\beta < a_{ik}$, the follower does not have several choices because he cannot select the kth item.

Backtracking Phase

Backtracking is used to find an optimal solution (x_i^*, y_i^*) related to the optimal value obtained in the forward phase. In fact, the value of y^* is obtained by solving the reformulated problem in the second phase.

In the backtracking phase, dynamic programming is applied to the leader and to the follower problem. If, for a given k, the follower has several equivalent choices, the value of x_k^* is determined according to the profit of the leader. The procedure corresponding to the backtracking phase is presented below.

$\beta \leftarrow y_i^*$

for $k = n_i$ *to 2 do*

If $g_{k-1}^i(\beta) \neq g_{k-1}^i(\beta - a_{ik}) + c_{ik}$ *then*

if $g_k^i(\beta) = g_{k-1}^i(\beta)$ *then* $x_k^* = 0$

if $g_k^i(\beta) = g_{k-1}^i(\beta - a_{ik}) + c_{ik}$ *then* $x_{ik}^* = 1$

else

if $f_k^i(\beta) = f_{k-1}^i(\beta)$ *then* $x_{ik}^* = 0$

if $f_k^i(\beta) = f_{k-1}^i(\beta - a_{ik}) + d_{ik}$ *then* $x_{ik}^* = 1$

end if

$\beta \leftarrow \beta - a_{ik}$

end for

if $g_1^i(\beta) = 0$ *then* $x_{1k}^* = 0$ *else* $x_{i1}^* = 1$

In the next section, we show how to solve the reformulated problem obtained from the forward step of dynamic programming.

The reformulated problem: a multiple-choice knapsack problem

Before presenting the problem, we define first from each dynamic programming table the set $\Omega_i = \{(\hat{d}_j^i, \hat{a}_j^i) : j = 0,\ldots,p_i\}$ of p_i pairs $(\hat{d}_j^i, \hat{a}_j^i)$, which contain the non-dominated solutions of sub-problem sub_i; $\hat{d}_j^i$ represent the profits associated with the objective function of the leader $f^i(x_i, y_i)$ and $\hat{a}_j^i$ represents the consumed resources. Note that the set Ω_i is obtained by applying the forward phase of dynamic programming. As mentioned before, the optimal solution of BLPMF is the best solution obtained by the feasible combination of sub-solutions from the different sets Ω_i with i=1,…,s. In other words, from each set Ω_i we have to select only one sub-solution in order to maximize the total profit without violating the capacity b. This choice can be formulated through the following model.

$$
\begin{aligned}
&\underset{(x,y)}{Max}\ f(x,y) = \sum_{i=1}^{s}\sum_{j=1}^{p_i} \hat{d}_j^i z_{ij} \\
&\quad s.t. \\
&\qquad \sum_{i=1}^{s}\sum_{j=1}^{p_i} \hat{a}_j^i z_{ij} \le b, \\
&\qquad \sum_{j=1}^{p_i} z_{ij} = 1, \qquad i = 1,\ldots,s, \\
&\qquad z_{ij} \in \{0,1\}, \qquad i = 1,\ldots,s \quad j = 1,\ldots,p_i.
\end{aligned}
$$

This optimization problem is a multiple-choice knapsack problem (MCKP). The binary variables z_{ij} indicate the selection or not of the j^{th} sub-solution of the set Ω_i. The first constraint ensures that the total consumed capacity of the selected sub-solutions does not exceed the total capacity b. The second set of constraints are the choice constraints. They indicates that from each set Ω_i only one sub-solution can be selected. The optimal solution of this problem allows us to define the optimal value for the variables y_i^* in the following way:

$$y_i^* = \sum_{j=1}^{p_i} \hat{a}_j^i z_{ij}^* .$$

We know that any optimal solution for MCKP will select only one sub-solution from Ω_i. This selection is defined by the variable z_{ij}^* which takes the value 1. In this case, the value of y_i^* is equal to the associated consumed resource $\hat{a}_j^i$. When we determine the values of y_i^* for i = 1,…,s, we apply the backtracking phase of dynamic programming on each sub problem sub_i to define the optimal reaction of the group of followers $(x_1^*,\ldots,x_s^*)$. The problem MCKP is solved using a commercial solver. In our case, we resort to the CPLEX solver.

COMPUTATIONAL EXPERIMENTS

In this section, we report on computational experiments to evaluate the quality of our approach. The algorithm was coded in C++, and we used the commercial solver CPLEX 12 to solve the MCKP. The tests were conducted on a computer with a 2.4 GHz processor with 4 GB of RAM.

In Table 1, we report the computing time for each step of our algorithm: the computing time for the forward phase is given in column *F*. In column MCKP, we present the computing time spent by Cplex to solve the MCKP. The computing time for the backtracking step is not given because it is typically very small.

The instances were generated randomly by varying the number *s* of followers and the number of objects of each follower n_i. Each coefficient of the problem is chosen randomly and uniformly from the interval [50,100].

s	n_i	F	MCKP
10	50	0.4	3.6
50	50	0.5	30.8
10	60	0.6	4.6
50	60	0.8	28.4
10	70	0.6	7.2
50	70	1.0	66.0
10	80	0.4	10.2
50	80	1.0	50.4
10	90	0.6	12.0
50	90	1.0	71.2
10	100	0.4	12.8
50	100	1.8	140.6

Table 1 - Computing time for each phase of algorithm

The results obtained for these instances show that the forward phase in our algorithm is fast compared to the other components. Its performance depends mostly on the value *b* of the knapsack constraint. Compared to the forward phase, the computing time required to solve the MCKP high. This is not surprising given the complexity of MCKP. For larger instances of the MCKP, an alternative may be to resort to a heuristic which can be obtained for example by setting a time limit for the execution of the solver, and using the incumbent solution obtained up to this time limit.

CONCLUSIONS

In this paper, we explored an exact solution algorithm for a bilevel optimization problem involving a single leader but more than one follower. The problem was solved using a two phase algorithm. The first phase is based on dynamic programming rules that are applied on a decomposed problem. Dynamic programming allowed us to define all the non-dominated solutions of each decomposition problem of the main problem. In the second phase, we combined these non-dominated solutions to find an optimal one. For this purpose, we modeled this process using an integer programming model. The related problem is a multiple choice knapsack problem which is solved using commercial solver. The algorithm is competitive for medium size instances.

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ON THE ADEQUACY OF ENTROPY IN ASSESSING STOCK MARKET VOLATILITY

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Abstract: A survey on the subject shows that the standard deviation is the most commonly used measure of stock market volatility. However, given its major drawbacks we propose an alternative approach based on the concept of entropy, whose main advantage is to make possible a more comprehensive description of such volatility. In view of the fact that the Shannon entropy is only suitable for describing equilibrium systems we consider the Renyi entropy, which is a more appropriate measure to deal with anomalous systems. The results show the limitations of the standard deviation-based approach in fully characterizing the oscillations of volatility.

Keywords: finance, finance_features, statistical_methods, risk, turbulent enviroment, stock_trading, risk_assesment

1. INTRODUCTION

The intricate character of stock markets has always intrigued both scholars and practitioners alike. One major issue in this debate has been the different patterns evidenced by stock market volatility. In spite of its present relevance, this is not an entirely new issue and has emerged in a systematic way when Shiller [1] first argued that the observed stock market volatility was inconsistent with the predictions of present value models, quite popular in the past. Moreover, Grossman and Shiller [2] have found that the intemporal variation appeared to be inexplicably high and could not be rationalized even in models with a stochastic discount factor. Even though some authors have questioned the conclusion of excessive volatility, like Flavin [3] or Kleidon [4], latter tests accounting for dividend nonstationarity and small sample bias lend support to Shiller's initial claim (see Refs. [5-9]). A new insight into this matter was brought by Schwert [10], who asked the seminal question "Why does stock market volatility change over time?", having reached the conclusion that only a small amount of fluctuations could be explained by models of stock valuation. On the light of this, many other studies have appeared, giving rise to an intense debate on the subject.

If the definition of volatility is, itself, important, its measurement is fundamental for practical purposes. However, since volatility is not observed, there has been no agreement on how to measure it, thus emerging a plethora of techniques. Given the controversy that has emerged around the use of the traditional methods, a different approach that relies on the concept of entropy is proposed in this study. The concept of entropy was originally introduced in 1865 by Clausius in the context of Thermodynamics. However, since then, several formulations have been developed. Despite the debate over its meaning, it is generally understood as a measure of disorder, uncertainty, ignorance, dispersion or even lack of information.

In our analysis, we estimate the Renyi entropy in order to assess stock market volatility. This measure, originally introduced in the domain of physics, has proven to be especially useful in describing financial phenomena; thus giving rise to a new branch of knowledge called Econophysics. In an analogy with terms like Biophysics, Geophysics and Astrophysics this word was introduced by Stanley *et al.* [11] as an attempt to legitimize the study of Economics and Finance by physicists. One argument was that some regularities were found between these two areas. Another one points out the benefits of the experimental method commonly used in physics, which departs from the observed data without imposing any previous model. Also, it is worthy to note the evidence of common research interests between these two fields. As Mantegna and Stanley [12] have already pointed out, the characterization of prices changes, *i.e.*, volatility is an active domain of research in Physics.

In our study we apply the concept of entropy to capture the presence of complex dynamics in the G7's stock market major indexes: TSX 60 (Canada), CAC 40 (France), DAX 30 (Germany), MIB 30 (Italy) NIKKEI 225 (Japan), FTSE 100 (UK) and S&P 500 (USA). The empirical analysis is conducted based on the Datastream database.

The remainder of the paper is organized as follows: Section 2 discusses both the concept of volatility and entropy, Section 3 presents the empirical findings and, finally, Section 4 draws the conclusions.

2. VOLATILITY AND ENTROPY: SOME CONCEPTS

In this Section we discuss several measures of volatility. We begin with the most common one – the standard deviation – and then analyze the Shannon and Renyi entropy. Before proceeding any further a clarification about its meaning is necessary. According to many researchers, volatility can be broadly defined as the changeableness of the variable under consideration (see [1] and [13], for instance). Hence, this term has been popularized as a synonymous of risk and uncertainty.

Based on the fact that volatility might not be constant over time, *i.e.*, volatility is volatile, some authors have divided the various techniques in two broad categories: time invariant (or independent) and time variant (or dependent) measures. The first group includes the techniques studied in this paper, since they do not depend on time. The other one clearly exceeds the scope of this research and is related to, for instance, the ARCH-type models (Autoregressive Conditional Heteroskedasticity Models).

2.1 A traditional measure of volatility

Most empirical studies in finance focuses on the assets returns r_t expressed as

$$r_t = \ln P_t - \ln P_{t-1}, \qquad (1)$$

where P_t and P_{t-1} denote the prices at time t and $t-1$, respectively. A popular way to measure stock market volatility is to compute the corresponding standard deviation over some historical period T, given by

$$\sigma = \sqrt{\frac{\sum_1^T \left(r_t - \overline{r}\right)^2}{T-1}}, \qquad (2)$$

with $\overline{r}$ representing the sample average return, $\overline{r} = \sum r_t / T$.

Although this measure has some advantages since it is simple to calculate and is able to capture the probability of occurring extreme events, it also shows some drawbacks. One, is that it could lead to an abrupt change in volatility once shocks fall out of the measurement sample. And, if shocks are still included in a relatively long measurement sample period, then an abnormally large observation will imply that the forecast will remain in an artificial high level even though the market is tranquil. Secondly, it assumes that recent and more distant events are equally weighted. However, the most likely situation is that the more recent ones have a stronger effect on volatility than the older ones. Finally, it only captures linear relationships, ignoring all kinds of nonlinear dynamics.

Nonetheless, it is worthy to note that, in spite of all the flaws that have been noticed by a wide body of research, the standard deviation is still the most popular volatility measure, being used as a benchmark for comparing the forecasting ability of more complex models.

2.2 Entropy as a measure of volatility

An alternative manner to study stock market volatility is by applying concepts traditionally used in statistical physics. In order to describe the volatility complex dynamics one measure that can be used is the concept of entropy. This concept was originally introduced in 1865 by Clausius to explain the tendency of temperature, pressure, density and chemical gradients to flatten out and gradually disappear over time. Based on this, Clausius developed the so-called Second Law of Thermodynamics, which postulates that the entropy of an isolated system tends to increase continuously until it reaches its equilibrium state. Although there are many different understandings of this concept, the most commonly used in literature is as a measure of ignorance, disorder, uncertainty or even lack of information (see Ref. [14]).

Later, in a subsequent research, Shannon [15] provided new insights into this matter showing that entropy was not only restricted to Thermodynamics but could also be applied to any context where probabilities can be defined. In fact, thermodynamic entropy can be viewed as a special case of the Shannon entropy since it measures probabilities in the full state space. Based on the Hartley's formula ([16]), Shannon [15] derived his measure of entropy and established the foundations of the information theory.

For a given a probability distribution $P = \{p_i\}$ ($i = 1,...,N$) Shannon entropy $S(X)$, reads

$$S(X) = -\sum_{i=1}^{N} p_i \log p_i, \qquad (3)$$

where $0 \log 0$ is defined as 0 and the normalized associated probabilities $\sum_{i=1}^{N} p_i = 1$.

Shannon entropy has been most successful in the treatment of equilibrium systems in which short/space/temporal interactions with ergodicity and independence dominate. However, there are in nature many anomalous systems that do not verify the simplifying assumption of ergodicity and independence ([17], [18]). Some examples in physics include: metaequilibrium states in large systems involving long range forces between particles; metaequilibrium states in small systems (100-200 particles); glassy systems; some classes of dissipative systems, mesoscorpic systems with nonmarkovian memory, and so on. This also applies to financial systems, especially in those cases where markets are subject to changing turbulence over time, e.g. stock markets ([19], [20]).

Renyi [21] proposed the first known generalization of the Shannon entropy. Firstly, introduced in the context of the Information Theory, it rapidly found application to other scientific domains ([22]), such as, statistics ([23]-[25]), digital image segmentation ([26]), complex systems ([27]), quantum mechanics ([28]) or even cosmology ([29]). However, there is little evidence of the application of the Renyi entropy to financial systems and our work constitutes one of the few exceptions. Renyi entropy is commonly regarded as a major advance in the description of more realistic situations from the point of view of the communication engineering ([30]).

The starting point of Renyi [21] was the general notion of mean and quasi-linear or quasi-arithmetic mean of a random variable X, independently introduced by Kolmogorov [31] and Nagumo [32], given by

$$E_{\varphi}X = f^{-1}\left(\sum_{i=1}^{n} p_i f\left(X_i\right)\right) \tag{4}$$

where f denotes an arbitrary continuous and strictly monotonic function usually known as the KN – Kolmogorov-Nagumo function. If f is linear we have the special case of the linear mean. The Renyi entropy, also known as the Renyi information of order α, can be written, in the discrete case, as

$$S_{\alpha}\left(X\right) = \frac{1}{1-\alpha}\log\left(\sum_{i=1}^{n} p_i^{\ \alpha}\right), \tag{5}$$

with $\alpha > 0$ and $\alpha \neq 1$, where α denotes the generalization parameter. When $\alpha \to 1$, the Renyi entropy converges to ($S\left(X\right)$). While the Shannon entropy is simply a measure of the average gain of information, the Renyi entropy represents the exponential average of the gain of information associated with event i ([33]).

Despite its advantages, the use of the Renyi entropy in empirical work was relatively inexpressive because of the ambiguous renormalization for continuous distributions and the difficulty in interpreting the α generalization parameter (see, however, [34]).

This entropy measure is characterized by a set of axioms that lead to the following major properties:

1. If $S_{\alpha}\left(Y \mid X\right)$ represents the conditional entropy then $S_{\alpha}\left(Y \mid X\right) = 0$ if and only if Y is uniquely determined by X.
2. If X and Y are independent, $S_{\alpha}\left(Y \mid X\right) = S_{\alpha}\left(Y\right)$ and $S_{\alpha}\left(X \cap Y\right) = S_{\alpha}\left(X\right) + S_{\alpha}\left(Y\right)$.
3. Rewritting the Renyi entropy on the basis of the KN mean and, if the results of a given measurement have information of order α, then they must be weighted by $\rho_i\left(\alpha\right)$.
4. $S_{\alpha}\left(X\right)$ is concave for $0 < \alpha < 1$.
5. For $\alpha > 1$, $S_{\alpha}\left(X\right)$ is neither strictly concave nor strictly convex and cannot be then considered as a physical entropy ([35]).
6. $S_{\alpha}\left(X\right)$ is a monotonic decreasing function of α, *i.e.*, its first derivative is ≤ 0.
7. $S_{\alpha}\left(X\right) \geq S_1\left(X\right)$, $\forall \alpha \in \left(0,1\right)$, where $S_1\left(X\right)$ denotes the Shannon entropy.

3. EMPIRICAL ANALYSIS

This Section explores the empirical relevance of the theoretical results obtained from the estimation of the Renyi entropy. To this end, we have collected data from the G7's countries. This analysis is especially relevant in the context of the global financial crisis we are living in, which also constitutes another area of research.

3.1 Data

The data set comprises the daily returns of the G7's major indexes: TSX 60 (Canada), CAC 40 (France), DAX 30 (Germany), MIB 30 (Italy), NIKKEI 225 (Japan), FTSE 100 (UK) and SP 500 (US) spanning from 4 January 1999 to 21 January 2009. A total of 2623 observations were used for each series, which represents more than 80% of the local market value. Fig. 1 depicts the long-term pattern exhibited by the seven price series under study.

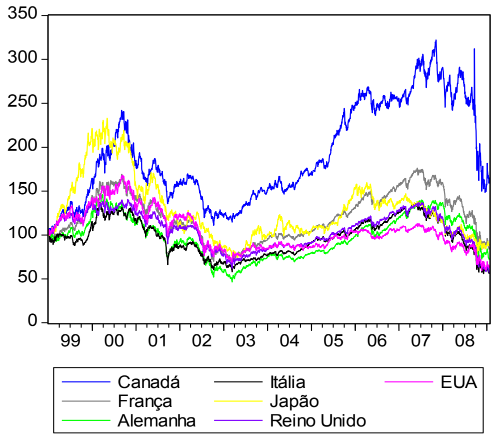

Fig. 1. Daily closing prices in the stock markets for the G7's countries over the period 4th January 1999 to 21st January 2009

In general, all indexes show evidence of changing volatility, with special emphasis towards the end of the period. Tables 1 and 2 present some descriptive statistics for the daily returns.

Table 1- Descriptive Statistics for the S&P/TSX 60, CAC 40, DAX 30, MIB 30, NIKKEI 225, FTSE 100 and S&P 500 returns

Statistics	TSX 60	CAC 40	DAX 30
Mean	0.00019	-6.87E-05	-0.00012
Median	0.00071	0.00027	0.00045
Maximum	0.19764	0.0992	0.16046
Minimum	-0.23688	-0.08429	-0.07211
S.D.	0.01498	0.01361	0.01318
Skewness	-0.93969	-0.05697	0.50586
Kurtosis	42.7449	8.28517	15.2568
J.-B. Test	172963.6**	3053.1**	16524.2**

Notes: ** indicates the rejection of the null hypothesis at the 1% significance level. * indicates the rejection of the null at the 5% significance level

Table 2 - Descriptive Statistics for the S&P/TSX 60, CAC 40, DAX 30, MIB 30, NIKKEI 225, FTSE 100 and S&P 500 returns

Statistics	MIB 30	NIKKEI 225	FTSE 100	SP 500
Mean	-0.00022	-3.92E-05	-0.00021	-0.00016
Median	7.69E-05	0.00017	8.22E-05	0.00017
Maximum	0.10482	0.10367	0.09004	0.10307
Minimum	-0.08636	-0.0779	-0.08929	-0.0901
S.D.	0.01253	0.01504	0.01343	0.01501
Skewness	-0.1294	-0.208	-0.17521	-0.01142
Kurtosis	10.2905	5.7612	9.41841	7.6785
J.-B. Test	5814.2**	851.9**	4514.1**	2391.4**

Notes: ** indicates the rejection of the null hypothesis at the 1% significance level. * indicates the rejection of the null at the 5% significance level

From a statistical point of view there is evidence of negative asymmetry for all the time series considered, except for Germany. All returns exhibit excess kurtosis with the highest value for Canada and the lowest for Japan. As a consequence, unconditional normality is significantly rejected at the 1% level in all cases (Jarque-Bera test). There is, therefore, strong evidence of fat-tails for all series, as expected.

3.2 RESULTS

We now turn to the Renyi entropy, whose results were estimated with histograms based on equidistant cells. Fig. 2 plots the entropy results over the interval $1 \le \alpha \le 3$. As expected, the value of the entropy declines at a decreasing rate as $\alpha \to 3$ and converges to zero as $\alpha \to \infty$.

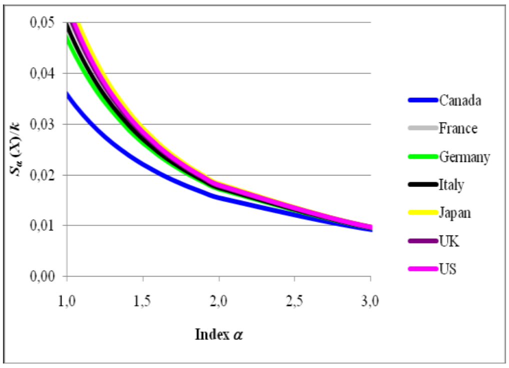

Fig. 2. Results of $S_\alpha(X)/k$ for $1 \le \alpha \le 3$

Another interesting feature is that the normalized entropy $S_\alpha(X)/k$, for different markets tends to be similar as the entropy parameter increases, although some differences do arise for smaller values of α with, for instance, the entropy for Canada being smaller than the entropy for the remaining countries in our panel.

Over the interval $1.4-1.5$, the difference among the entropies becomes more evident. The lowest entropy is observed for Canada while the highest one belongs to Japan. The latter, however, also exhibits the smallest kurtosis, as observed before.

Fig. 3, therefore, appear to emphasize the extent of market risk for each of the G7's countries, which is not so evident when one simply looks at the standard deviation shown in Tables 1 and 2. For example, on the basis of the standard deviation Japan and US present the highest risk whilst Italy and Germany show the lowest one. Differences between them are not nevertheless very sharp. However, on the basis of the entropy results, the lowest risk countries are now Germany and, by far, Canada, with a big gap between the latter and the other markets.

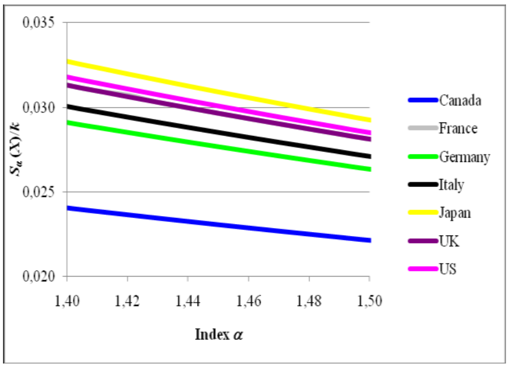

Fig. 3. Results of $S_\alpha\left(X\right)/k$ for $1.4 \leq \alpha \leq 1.5$

The results above show that the smaller the value of α, the bigger the value of $S_\alpha\left(X\right)$, that is, the greater is the uncertainty traditionally associated to rare events; its importance decreases as $\alpha \to 1$ (Shannon entropy).

In the overall, it appears that the use of entropy as a measure of volatility enables better insights over the identification of risky markets by distinguishing them more sharply than when we simply apply the standard deviation. For the moment, however, it suffices to recognize that the Renyi entropy can be used to describe stock market volatility.

4. CONCLUSIONS

In this paper we have investigated whether entropy can be used to measure stock market volatility by analyzing the behaviour of seven indexes over a period of about ten years, comprising periods of relative stability with others of high instability.

The entropy results appear to provide a better picture over the risky pattern of the countries than the more fuzzy results based on the standard deviation. The results point out to a volatility complex dynamics. This is especially relevant for the decision making process in which all the information is regarded as necessary and useful.

Finally, we acknowledge that the use of entropy allows us to capture the uncertainty and disorder of a time series without imposing any constraints on the theoretical probability distribution, which constitutes its major advantage.

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LEAN VS.AGILE IN THE CONTEXT OF COMPLEXITY AND SUSTAINABILITY MANAGEMENT IN ORGANIZATIONS: A CONTRIBUTION TO THE R&D PROGRAMS FORMULATION

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Abstract: Complexity and sustainability management is one of the most important requirements for nowadays organizations considering the ever growing degree of the environment dynamics. In addressing these two issues there is a number of approaches. However, it seems that the most present in organizations are the so-called approaches '*lean*' and '*agile*' (management). As these two approaches, *lean* and *agile* could be understood as conceptually different, there is a question how these two approaches addresses the requirements for the complexity and sustainability management. In other words, the question is on their capacity to address the complexity and sustainability management in organizations, as well as their mutual relationship and conditions of applications.

In this paper it is presented a comparative analysis of the principles of *lean* and *agile* management approaches, considering the principles of the complexity and sustainability management from the Chaordic System Thinking (CST) perspective, where CST is assumed as a model for the complexity and sustainability management in organization.

The paper is structured through three global parts. In the first part the concepts of *lean*, *agile* and CST are presented. The second part presents the comparative analysis of the *lean* and *agile* management approaches from the CST perspective. And the third part presents conclusions and some suggestions for R&D programs formulation.

Keywords: Lean, Agile, Complexity, Sustainability, Management

FIRMS AS TEAMS

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Abstract: This paper proposes the concept of a firm being totally constituted by a team over time and sketches some of its consequences.

Keywords: Networks of firms, partnership, teams.

THE CONCEPT OF FIRMS AS TEAMS

In this paper, we build on the definition of team presented by Katzenbach and Smith (1993):

> *A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they are mutually accountable.*

Teams are currently viewed as high-performance working groups inside larger organizations, be these public or private. Despite high-performance, team members are dependent on the organization they are in for income. One can ask "What if one would conceive of teams that would ensure the income to their members?" Under reasonable assumptions, it comes out that such teams should present themselves in markets as firms. This means that the "common purpose" of team members must be to ensure income to their members, or better, financial independence, in the condition of the team operating as a firm in a market.

A team can constitute a firm and, indeed, that must be a common phenomenon (Murta, 2011). Yet, once constituted, it is not of necessity that the firm in the overall continues to be a team. Therefore, one can ask another question: "What if once established as a firm, the team deliberately chooses to maintain the firm as a team?" Requiring that the firm continues operating as a team introduces a novel dimension for what a firm can be and for its relations to other firms.

This paper proposes the concept of a firm being totally constituted by a team over time. It sketches some consequences of this concept, namely:

– Its size and the fundamental interpersonal relationship of a firm as a team;

– The creation process and reproducing the firm as another firm;

– Interactions of such firms with other firms and their association in networks.

SMALL SIZE AND PARTNERSHIP

It is an established fact in literature that a team can only accommodate growth in the number of people up to a small number threshold, typically somewhere in the interval of ten to twenty. Past the threshold, the group of people no longer functions as a team, mainly due to natural limitations in the human capabilities of perception, cognition and communication. These limitations make practically impossible that the group remains "committed to a common purpose, performance goals, and approach" maintaining "mutual accountability". Therefore, if a firm must be a team, then the number of persons in it must be small.

Being a team dictates the firm has a small size and also requires that the employer-employee relationship (Ellerman, 2000) cannot exist inside the firm. The team in a 'firm as a team' has as top common purpose to realize financial independence for its members, with a common approach and inside a frame of mutual accountability. An employee in such a team could not share the common purpose because, by definition, being an employee means that one is not financially independent. If the common purpose is not shared, sharing the approach and performance goals does not make sense.

Furthermore, mutual accountability in the frame of an employer-employee relationship is severely limited. The accountability of the employer is limited to pay the wage or salary if the employee performs a stream of specified services; the accountability of the employee is limited to perform the stream of specified services for the contracted pay or salary. Such limited mutual accountability is not enough for the high levels of mutual accountability that characterize teams. Therefore, firms as teams should only count partners as their members or, in other words, realize complete partnership inside the firm.

In the literature, teams are consistently referred as attaining superior performance to any other organization form of small sized groups. Firms as teams should then be more efficient than same sized firms that are not teams. Complete partnership appears then as a necessary correlative of the firm being more efficient than same sized firms that are not teams.

CREATION PROCESSES OF FIRMS AS TEAMS

For a firm as a team to come into existence, two processes come at mind. These are the only processes available if firms as teams do not exist. In the first process, a group of people working in a given organization, having attained the team level of collaborative work and decision, abandons the organization and establish itself as a firm. Changes implied in the team relate to acquiring and maintaining competences to realize financial independence status. In the second process, a group of people can intend to create a firm as a team, without previously having attained the team level of collaboration. Such a group must become a team along the firm's creation process.

In any case, if the group of people is successful in creating and maintaining a firm as a team, then, as any other firm, it will grow in business volume and that requires more people in the firm. As referred above, a given team can only accommodate growth in the number of people up to a small number threshold. Having attained the threshold, a firm as a team must stop growth in the number of people.

A firm as a team must stop growth in the number of people to avoid losing its team condition and consequent high efficiency advantage. This can occur naturally if the firm exhausts its market potential growth at below or the threshold number of people. But if the firm has ample potential to grow, stopping growth appears as a frustrating decision that can undermine the team's cohesion. How can this problem be solved?

Out of buying other firms, firms grow by establishing a positive feedback with the market they operate in. The value they generate for customers elicits from the market a response of growing demand for the firm's products or services. This, in turn supports further investment of the firm in itself which serves the increased demand. The process can be abstracted to a growing firm creating a surplus for itself that feeds its growth. Now, if the surplus exists and growth is limited where the surplus can go?

An answer inspired from biology is that the surplus should grow to the creation process of other firms as teams. This preserves the team condition and can strengthen the firm's position in the business ecology by changing the ecology in a direction especially favourable to the firm. As the number of firms as teams increase, so resilience and efficiency of individual firms do, through the twin processes of cooperation and competition.

Therefore, solving the problem of stopping growth reveals a third process creation for firms as teams.

NETWORKS OF FIRMS AS TEAMS

To keep itself as a team, a firm as a team cannot hire people. Therefore, it must contract with other firms or individual professionals the provisioning of any services that it cannot provide to itself. There is no reason to believe that the relationship of a firm as a team with other firms in the market should present characteristics markedly different from those that we observe now.

The high efficiency of teams should give to firms as teams a competitive advantage over usual firms of the same size. Therefore, in the business ecological niche of small size, firms as teams appear well positioned not just to survive but also to prosper. The limiting factor to the spread of such firms will be the capability of people to become a team in the process of firm creation. No doubt, many of such processes can fail, as creating a team is not a trivial process and as long as the knowledge about teams remains restricted.

Yet, if firms as teams spread, then a supply of firms with a distinctive common culture emerges. These firms will share high-efficiency, small size, complete partnership, and a team way of doing things. It is to expect that they will associate themselves in networks. Through this process, associations or partnerships of teams of firms can address higher business volumes.

Networks of firms as teams open the possibility to address business volumes that individual firms cannot address. Higher business volumes together with cooperation and competition intra and inter networks will feedback positively on the resilience and efficiency of individual firms. Therefore, prospects emerge for firms as teams to become a sustainable and stable part of the business ecology.

CONCLUSIONS AND RESEARCH

This paper proposed the concept of a firm being totally constituted by a team over time and sketched some of its consequences. The motivation to start with is the recognition that a (true) team has greater performance than a comparable group of people that does not work as a team. Therefore, all other things equal, such a firm must have superior performance and competitive advantage.

The paper sketched the consequences of the concept in terms of firm's size and the fundamental interpersonal relation of complete partnership among members; creation processes pointing to reproduction; the character of interactions of such firms with others and the potential of firms as teams structuring themselves into associations or aggregates.

In a social situation where unemployment is high, especially for young people including those with tertiary education, the concept of a firm as a team can help to find ways for people to become financially independent.

Creation of firms by teams should reveal to be a not uncommon process. If the process is successful and firm's business grows, then the firm begins hiring and a usually organized firm appears. But, if the team decides to keep the firm as a team, growth of the firm is limited and must metamorphose to facilitating the creation of other firms as teams. Potentially, the usual ecology of businesses can change as firms as teams replicate and structure themselves in networks. Immediate research on the concept should consider:

– The creation processes of firms as teams in detail;

– The formation of networks of firms as teams, their structuring, operation and capability to grow.

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LEAN PRODUCTION PROMOTES THINKERS, NOT "ANDROIDS"

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Abstract: This paper presents the role of the Lean Production paradigm as promoter of the workers' human potential. In the literature it is possible to find out many authors who have a negative opinion about Lean Production and consider this organizational model as an extension of Taylorist/Fordist model where the worker is seen as a gear in the "big machine". Based on literature review and on the Toyota Production System (TPS) principles and history (later coined as "Lean Production"), and by comparing this with other systems, it will be attested that Lean Production is a work organizational model where the worker assumes a position of thinker, continuously looking for improvement. These workers-thinkers are the base for the Learning Organization.

Keywords: lean manufacturing; human potential; learning organizations

INTRODUCTION

Lean Production (LP) is a well proven organizational model implemented in different industries and services. Coined by the engineer and MIT researcher [1] John Krafcik to nominate the Toyota Production System (TPS) [2], the designation LP has become internationally known due to the book "The Machine that changed the World" from Womack et al. (1990) [3]. This book was followed by another one, from the same authors, titled "Lean Thinking" [4], and intended to guide companies so they can take advantage of LP. Lean Thinking has five main principles: i) create value for the customer; ii) map the value stream; iii) create flow; iv) pull production (customer pulls the production) and v) pursuing perfection. The implementation of these principles within the companies leads to the reduction/elimination of waste (*muda*, in Japanese). Waste is everything that does not directly contributes to add value to a product, under the perspective of customers' needs and requirements.

The paper's objective is to demonstrate that Lean Production, when compared to other work organizational models, promotes thinkers and not just workers who only execute what someone tells them to do. In order to achieve this objective, the paradigmatic work organization models will be reviewed along with the more recent systems thinking approaches that could, or not, stimulate/promote thinkers.

The paper's structure includes five sections. The first introduces the theme. The methodology is presented in the second section. The literature review is presented in the third section and the fourth section develops the discussion. Finally, the concluding remarks are presented in the fifth section.

METHODOLOGY

This paper relies on a literature review about: i) Taylorist/Fordist System; ii) Socio-technical System; iii) Toyota Production System/Lean Production iv) Agile Manufacturing and v) Chaordic Systems Thinking, based on a number of publications that were considered relevant to this discussion. An accurate analysis of the referred systems has highlighted their differences and revealed how each one of them deals with the human factor. These topics provide an exploratory discussion.

LITERATURE REVIEW

This section presents a review on the main organizational models of work (see previous section), emphasizing the role that each one of them attributes to the worker.

Taylorist/Fordist System

Taylor´s Principles of Scientific Management (1911) fit well in work organizations at a time when the number of unqualified human resources was very large (mainly due to rural people that came from countryside to the new cities). Henry Ford adopted these principles and gave employment to those people in his automobile factory. Therefore, even with unskilled workers, Ford was able to improve productivity (when compared to traditional craft production) and to produce large quantities of his famous car model, creating thus the mass production concept (single product, high production volume). Such achievement was possible due to the principle of work division, which divides the operations into elementary tasks that anyone could perform. Each operator stays permanently in one workstation performing his simple repetitive task, within a standard time previously estimated by the time and methods staff. Functions such as product engineering, process design, production planning and control or quality control, along with decision-making tasks, are assigned to other employees or to the managers. As the operators are not involved in these functions, they have no relevant responsibilities, being thus excluded from the active participation on the improvement of processes and products. Saying that the operator *"does not have to think, only to obey and execute"* reveals an approach centred on the command-and-control hierarchic chain.

The emphasis is on the individual and on the individual specialization to the execution of one task at some point in the assembling line, i.e., one individual, one workstation and one task. This work organization model restricts the mobility of operators between tasks, their participation in solving problems and their creativity. Therefore, it imposes severe and hard work conditions, considering the worker as a gear of the "big machine", totally dependent on the equipment. For these reasons the system was designated as a Techno-Centric System and has been extremely criticized [5], [6].

As a consequence of the Techno-Centric System, operators are isolated and do not share experiences and knowledge. The promotion of operators is compromised because they are denied the opportunity to learn in order to perform other tasks. Consequently, stress and aggressive and/or angry behaviours are prone to occur. This disequilibrium provokes musculoskeletal lesions, work dissatisfaction and absenteeism. The famous Charlie Chaplin's movie "Modern Times" (1936) is a clear critic to the hard conditions on the factories at that time, which led to countless manifestations and strikes (Fig. 1.).

Fig. 1. Scene of Charlie Chaplin's film "Modern Times"

Socio-Technical System

The Socio-Technical System (STS) is defined as a system based on the utilization of skilled human resources and flexible technology adapted to the needs of a flexible and participative organization [7]. These authors also designate this as Anthropocentric Production System, to contrast with the Techno-Centric System previously described. The STS promotes the operators' qualification, teamwork, mobility and the empowerment of team members. Multi-skilling, job rotation, job enlargement and job enrichment were strategies adopted to achieve this and to avoid the worker' boredom and the injuries caused by repetitive tasks [8].

Semi-Autonomous Work Groups (SAWG) or Self-Directed (or self-managed) Work Teams (SDWT), constitute the work organization model adopted by the Socio-Technical System [9], in opposition to the individual job developed in the Fordist system. In the 70 and 80´s [10], the Volvo automobile factories of Kalmar and Uddevalla were the best known examples of the application of this system. It is for this reason that is also known as the "Volvoísm" model. According to this model, each team is responsible for the entire assembly of the car. The democratization, the self-management, the participation of all members in the local decision-making (previously assigned to supervisors or managers), are fundamental characteristics of these teams [11], [12]. The team has autonomy to manage their tasks (what to do and how to do it) [12]. Reduction of hierarchic levels of management and the promotion of cooperation and creativity are results of the team empowerment and responsibility [13].

Toyota Production System and Lean Production

The mentors of Toyota Production System, Kiichiro Toyoda, his cousin Eiji Toyoda and the engineer Taiichi Onho, visited American companies to learn how to build automobiles. They learn a few things inside the company but mainly outside, for example in the supermarket where the kanban idea has emerged. Besides the identification of several inefficiencies in the mass production system, they also recognized that the Japanese market restrictions (e.g. low volumes and relatively high diversity) would derail that production system in their factory. Thus, the need for a new type of production system became clear, and that was the starting point for the development of the Toyota Production System (TPS). Additionally, they want a different way to treat persons in order to potentiate the Japanese workers' capabilities - Sugimori et al. [14] called this *"...the 'respect-for-human' system where the* *workers are allowed to display in full their capabilities through active participation in running and improving their own workshops".* Later, the TPS pillars and tools were published, presenting four key concepts supporting this system: JIT (Just-In-Time), autonomation, flexible work force and creative thinking or inventive ideas, *"…which means capitalizing on worker suggestions"* [2].

Some concepts like JIT, kanban, or others, come to the West but sometimes without the proper contextualization and integration, being referred as "the Japanese system". It was necessary a book launched by the MIT to attract the attention of managers and academics for that "Japanese system" that would became known as "Lean Production" [2]. This designation arose because TPS promotes *"doing more with less"*, when compared to the mass production. Less of everything: less human effort, less space, less stocks, less investment in new tools to produce higher diversity of products. Moreover, the lean approach changes the way operators work, challenging them, continuously, to improve processes and operations. Working in lean environments means that each one has freedom to control its own work, which also implies responsibility at all levels. This could cause some stress and anxiety as workers are responsible for eventual costly mistakes. But, on the other hand, it could also signify a meaningful, fulfilling and motivating work. Of course, this work environment calls for different attitudes and for the learning of new skills, including "soft" skills like teamwork, communication skills, problem-solving, creativity and systems thinking. An ex-president of Toyota [15] said "T" in TPS is "Thinking" and TPS really means a winning strategy for developing people in the global manufacturing environment. As management tools are less important than the mindset (as explained by Toyota senior executives [16]), the implementation of TPS is not easy. Mindset has to do with people. Toyota ex-president Watanabe, interviewed by Stewart and Raman [16], reaffirms the two main pillars of Toyota Way [17]: continuous improvement and respect for people, i.e. the employees, the supply partners and the customers (Fig. 2). By customer they mean not only the end customer but also the person at the next workstation on the assembly line. Continuous improvement means being all the time dissatisfied with the status quo and making small improvements that will accumulate and may become a revolution.

Agile Manufacturing

Agile Manufacturing (AM) was introduced in a report from Iacocca Institute about the 21st Century Manufacturing Enterprise Strategy ([18]; [19], [20]).

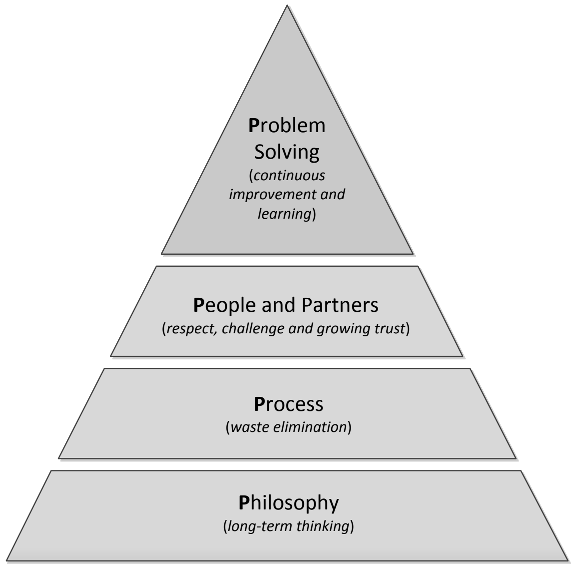

Fig. 2. The "4 P" model of Toyota way [adapted from 17]

Huang and Nof [21] refer that the agility of the company must be obtained from the business, organizational, operational and logistics systems agility. Kidd [19] reinforces the need of a methodology which integrates three fundamental elements to support the AM: i) organization, i.e., innovative structures of management and organization; ii) people supporting a knowledge base of skills and competences, and, (iii) technology (Fig. 3). Hooper et al. [22] appoints AM as an evolution of the process organizational flexibility with a focus on the client and on the product which originates the agile company.

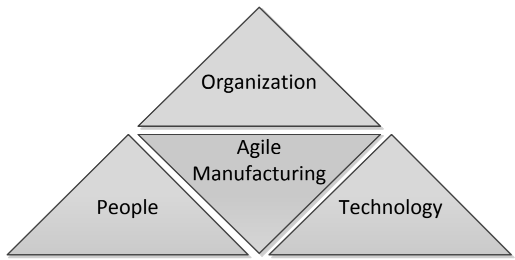

Fig. 3. The three fundamental elements of Agile Manufacturing

Agility is the system ability to easily adapt to the production of different products and/or different quantities of a same product. This implies fast changeover at reduced cost. A system with total agility means an instantaneous changeover at no cost. A system with total agility could produce mass customization products. Other definitions of AM could be found on [23]; [24] and [25].

Kidd [19] presented the AM nuclear concepts, identified as: i) strategy to achieve agility; ii) strategy to explore agility; iii) integration of organization, people and technology and iv) interdisciplinary methodology of design. The AM concurrency principles are: i) continuous change ii) rapid response; iii) quality improvement; iv) social responsibility and v) total focus on client. The same author proposed the AM characteristics: i) integrated enterprises; ii) human networking organization; iii) enterprises based on natural groups; iv) increased competences of all people v) focus on core competences; vi) virtual corporations; vii) an environment supportive of experimentation, learning and innovation; viii) multi-skilled and flexible people; ix) team working; x) autonomous groups and empowerment of all people in the enterprise; xi) knowledge management; xii) skill and knowledge enhancing technologies and xiii) change and risk management.

Chaordic Systems Thinking

According to van Eijnatten [26], *Chaordic Systems Thinking* (CST) is viewed "*…as a holonic approach to inform human interactions in a learning organization, in which the discoveries of the "new science" – chaos and complexity – are adopted in order to better understand discontinuous growth in complex social systems*". In this context, as defined by Senge [27], learning organization is an organization where learning and thinking are continuously promoted among people so they can expand their knowledge.

van Eijnatten [26] refers that CST does not represent the invention of a new paradigm, but rather the articulation, and eventual extension, of earlier approaches. The word "Chaord" result from the "chaos" and "order" and means "*…any self-organizing, adaptive, non-linear, complex organism, organization or community, whether physical, biological or social, the behavior of which harmoniously blends characteristics of both order and chaos*" ([28] cited in [29]).

DISCUSSION

From the work organization models and systems thinking approaches previously described, it is possible to put LP as a work organization model that has a deep concern about people and completely acknowledges that people is the most important asset of the companies. LP is totally opposed to Taylorist/Fordist system relatively to the people role in the company. Also in terms of the human factor, the other models, especially the most recent and not yet widely disseminated (AM and CTS), are aligned with the LP aims, namely workers empowerment, responsibility, creativity, ability to teamwork, communication skills, etc. However, some authors do not agree that lean effectively promotes the referred aims, but the authors of the present paper consider that these opinions are based on restricted views of reality, as explained next.

Over many years, the focus of many authors studying the TPS, e.g. [30], was the JIT system, autonomation and others, i.e., the technical part of the TPS. This partial understanding of TPS leads to a limited vision (sometimes distorted) of the system, pointing lean production as an intensified mass production or neo-Taylorism (in [31] and [32], cited in [33]). The main critics about lean refer ergonomics aspects with consequences on operators' health. Stressful and de-humanizing tasks are two of the mentioned aspects, but many authors have already reviewed and demystified these statements ([34] and [35]). Some authors also refer JIT and its benefits, ignoring the human aspect of TPS, discarding (on purpose or not) the importance and influence of this aspect on the success of industrial implementations.

The focus only in the technical system hides the most distinctive aspect of lean: the promotion of system thinkers. However, some authors are aware of this problem. For example, Spear and Bowen [31] saw what others didn´t see: beyond the technical system, and supporting this, was the fact that TPS creates a community of scientists which, when facing a problem or a need to change a technique, are encouraged and stimulated to raise hypotheses and to conduct experiments following the scientific method. These authors consider that in order to understand Toyota's success, it is necessary to unravel the paradox: *"you have to see that the rigid specification is the very thing that makes the flexibility and creativity possible."* According the same authors *"…this ensure that regular work is tightly coupled with learning how to do the work better*" [31]. Spear [37] reports a case about how young managers were trained and become problem identifiers and solvers. Liker [17] points out that a common phrase heard around Toyota is *"Before we build cars, we build people."* "Building people" means to develop people so they become strong contributors who can think and follow the Toyota Way at all levels within the organization. He also refers that the base for genuine long-term success relies on the company's leadership capacity to endorse the building of a Learning Organization. In fact, the non-utilization of human potential is referred as eighth waste [17].

The search for continuous improvement is, certainly, the type of behavior that conducts to a Learning Organization. Geus [38] defines the Learning Organization as a living company which has the capacity to learn. He referred that companies have a short life time cycle, "dying" younger. This is due to the managers who focus their attention only on producing goods and services and forgot that a company is also a community of people. The companies that stay alive, achieve this through several factors such as being sensible to the world around, adapting to this, taking conscience of its identity, making the people feel part of the whole and being receptive to new ideas, promoting this way the innovation and learning. Other definitions of the Learning Organization concept could be found in the literature and some of them are reviewed in van Eijnatten and Putnik [29]. These organizations make sense as the success can be promoted by mobilizing the intelligence available within each company. Toyota knows this and invests deeply in people and organizational capabilities. The employees are viewed *"…not just as pairs of hands but as knowledge workers who accumulate chie – the wisdom of experience – on the company's front lines."* and "*Toyota's culture of contradictions places humans, not machines, at the center of the company*."[39].

"How to change the culture: lessons from the NUMMI" is the title of a paper by Shook [40] that reports the success of NUMMI (New United Motor Manufacturing, Inc.). NUMMI was the first joint venture auto-plant between Toyota and GM where TPS principles were lived for the first time outside Japan. The first lesson was: start by changing what persons do, rather than how they think. In order to do the things right, the employees need means that companies must provide. It is unquestionable that people behavior could influence the corporate culture and affects negatively or positively the company success. Emiliani [41] wrote a paper about the lean and "fat" behaviors (making the analogy between lean production and batch and queue production) that guide a company to the company's prosperity or death. Lean is considered a philosophy by some authors, e.g. [42], since a successful implementation is a long term journey requiring the application of various technical tools, continuous improvement, and, numerous cultural changes engaging empowerment and sponsorship. Yamamoto and Bellgran [43] discuss the fundamental mindset and organizational learning behind the Lean production continuous improvement. The fundamental mindset is related to the fact that each improvement should start from a need. These needs must be felt and persons in the company are the only production factor with that capacity, being also able to develop solutions to fulfill these needs.

Lean implementations, normally, imply cultivating a Lean culture in order to sustain conversions [44]. This Lean culture only grows if adequate changing agents are permanently inside the company. The isolated application of tools by an outsider (e.g. from a consulting firm) which disappears after implementation, does not sustain a robust and lasting environment and is prone to failure. So, no one better than the company's workers may ensure a sustainable change. These situations are corroborated by several authors describing successful and unsuccessful lean implementations. The lean focus is on the continuously collective learning, and not on the permanent particular implementation. This collective learning implies teams, namely "Toyota team" and Lean teams. The different meanings of team, and the different behaviors of their members, are analyzed in [45]. These teams could promote the responsibility and active thinking, but could also have a malicious effect on the more individualist members [46].

The creative thinking in TPS was promoted by the introduction of "suggestions boxes" and many other companies adopted this practice. But this initiative is not sufficient if the system is not properly implemented, e.g., if an intermediary exists (for example: a supervisor that put the suggestion in the box and gives no credit to the operator).

CONCLUDING REMARKS

Several authors, such as Elton Mayo, Maslow, Herzberg, Schein and others, have been discussing, during different epochs, the importance of factors like motivation, teamwork, fulfilling, professional realization, and sense of ownership. These factors are more important than a money bonus or reward and, besides adequate ergonomic conditions, they are fundamental to improve workers' productivity. The people learn, feel, think and resist, and as a result, they are different from others resources and could not be treated the same manner. Additionally, in the current crisis, people could lead to the success or unsuccessful of the companies. The peoples' role must be rethought - their competences must be reviewed and improved because the demand is different, urging for teamwork, polyvalence, decision-making and assumption of responsibilities, self-learning and self-adaptation skills. After the Taylorist/Fordist system, this role has started to receive the proper attention and Lean production is one of the work organization models clearly involved in that aspect. Through this paper, Lean Production is evidenced as a model where the persons assume a role of thinkers, not "androids".

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A REVIEW OF AGILE AND LEAN MANUFACTURING AS ISSUES IN SELECTED INTERNATIONAL AND NATIONAL RESEARCH AND DEVELOPMENT PROGRAMS

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Abstract: The aim of this review paper is to analyze international and national research and development programs for manufacturing sector, comparing how agile and lean manufacturing models are addressed in these programs. Several manufacturing research and development programs – national programs from the United States and international programs from the European Union – are reviewed. The major finding of this review is that the main concerns in agile manufacturing, as highlighted in these programs, are networks, supply chain and product/service customization, and lean manufacturing's inclination towards achieving better cost efficiency. Although lean manufacturing approach has been considered in many past and present programs, analysis of the most recent programs show a greater priority is given to agile manufacturing approach. The findings of this review paper are intended to help managers, researchers and practitioners from the manufacturing sector to enhance their understanding and define suitable strategy for their organizations' sustainability and identify suitable manufacturing path. The path towards a sustainable manufacturing is delineated by pro-active attitude and action towards customers.

Keywords: R&D programs, Manufacturing management philosophy, Agile manufacturing, Lean manufacturing, Organization strategy.

1. INTRODUCTION

Research and development (R&D) programs, national and international, in manufacturing sector give their vision for the future of this sector and identify the research needed to face new challenges, such as those in the current turbulent environment. In fact, they act as strategic roadmaps for manufacturing, and underlying management philosophy perspectives for manufacturing. In this paper, a review of how the agile and lean manufacturing concepts are addressed in selected national and international R&D programs is presented.

In the selected R&D programs, the overall vision of each country/institution (national and/or international) is to be leader in the competitive market at global level, for example, as explicitly mentioned in programs of the United States (US) National Science Foundation and National Science and Technology Council [1], [2].

The manufacturing sector is considered a driver to create social sustainability, through direct and indirect employment, and economic sustainability, through economic growth [3]. R&D programs, at international and national level, are pushing manufacturing sector to go towards new technological solutions, new approaches and new paradigms [2], [4], [5], [6], [7], [8], [9], [10]. Sustainable manufacturing, ICT-enabled intelligent manufacturing, high performance manufacturing, and exploiting new materials (taking advantage of new materials/technologies) through manufacturing [11] are some examples of R&D program domains. Intrinsically to these domains, there is an implicit management philosophy and in this review, an analysis is presented about how the two management philosophies for manufacturing, namely, agile manufacturing and lean manufacturing, are addressed. This paper is organized in following sections. Section 2 is a comparison between agile and lean manufacturing from a selection of literature. The literature taken in consideration to this review is not an exhaustive material on the two concepts, but nevertheless some general differences between the two and also their genesis are presented. Section 3 is an overview of some national (from the US) R&D programs and some international (from the European Union) R&D programs, highlighting lean and agile manufacturing concepts' presence in them. Section 4 has conclusions, based on this review, about what is a general tendency to drive manufacturing stakeholders towards sustainable manufacturing industry.

2. AGILE MANUFACTURING VS LEAN MANUFACTURING

Agile manufacturing was introduced in 1991 [12] in the United States as a response to the Japanese management philosophy of lean manufacturing,developed in the 1950s by Eiji

Toyoda and Taiichi Ohno, also known as Toyota Production System [13]. In the specific case of Toyota' automotive industry, the lean manufacturing was developed to implement tools for mass production. The report, "21st century Manufacturing Strategy: An Industry-Led View" [12],which introduced the agile manufacturing, claims that the new criteria for competition advantage "belong to agile manufacturing enterprises, capable of responding rapidly to demand for high quality, highly customized, products."

Thanks to the natures of requirements for foundations/genesis of these two manufacturing concepts, it is possible to say that they are in two opposite sides of the management philosophies. In other words, one was created for masses (less customization and high volumes), and the other for individuals (with highly customizable production with low volumes). In Table 1, key differentiators are presented as previously published in [14].

Table 1 – Key differentiators [14].

	Agile	Lean
Drivers	• Customer • Economy of diversity • Unpredictable markets • Make to order	• Market • Economy of waste • Predictable markets • Make to forecast
Focus	• People and Information	• Technology and Systems
Suppliers	• Selection from many • High level of trust • (short-term) • Shared risk/reward	• Fewer • High level of trust • (long-term) • Co-operative
Organization	• Multi skilling • Empowerment	• Teaming • Flatter organization
Product	• Customized • Fitness for purpose	• Many options • High quality
Process	• Adaptive • Knowledge based	• Flexible • Automated
Philosophy	• Leadership	• Administrative

Referring to Table 1, the agile manufacturing is driven by customer and lean manufacturing is driven by market. In agile manufacturing, people and information are the focus, and, in lean manufacturing, technology and systems are the emphasis. These are two examples of opposite positions of the two manufacturing management philosophies in this study.

Some previous studies tend to combine the agile and lean manufacturing, adapting to a case and to supply chain, naming this combination as 'leagility' [15]. Although in one of the selected R&D programs discussed in the following section, this 'concept' is present,the hybrid concept is not considered for reviewing in this paper due to the ambiguity and lack of explicit position, it could be considered as a concept that tries to get the better of two sides, without any unique identity.

3. SELECTED MANUFACTURING RESEARCH AND DEVELOPMENT PROGRAMS

Worldwide many countries and organizations create their own visions of what should be R&D direction for manufacturing. These visions are usually expressed through programs which lay out the individual countries' and organizations'desired strategic paths towards sustainable manufacturing organizations in future.

There are numerous R&D programs for manufacturing sector, by different countries/regions, for e.g. Seventh Framework Programme (FP7) in European Union (EU), or global organizations like IMS (Intelligent Manufacturing Systems), but for this review some of the R&D programs that explicitly refer the two manufacturing management philosophies – agile manufacturing and lean manufacturing – were considered. These selected programs were divided into two categories: national programs and international programs.

The national programs address to a specific country's R&D programs for manufacturing, i.e., national R&D strategy for the future of manufacturing sector of a country. This study refers to two of the existing national R&D programs in the United States. The international programs refer to international R&D programs for manufacturing, i.e. international organizations that prepare R&D programs towards manufacturing competitiveness and sustainability. In this paper, European Commission's (EC) R&D programs in manufacturing are referred as international programs.

National Programs

Report: America's Investment in the Future – chapter "Manufacturing"

In the National Science Foundation's (NSF) report "America's Investment in the Future", in a chapter titled "Manufacturing – the form of things unknown," there are inputs (suggestions) for success of the American manufacturing sector [1].The contribution of the chapter is to define guidelines for investment in innovative research and education in the American manufacturing sector.

Concerning the subject matter of this review paper (agile vs. lean manufacturing), the agile manufacturing is referred from two perspectives in the above mentioned chapter from the NSF report: 1) educational and 2) manufacturing management. From the educational perspective, innovative educational programs to transform manufacturing enterprises into agile manufacturing enterprises are proposed for implementation. These educational programs aim to change actual traditional factories into agile factories and prepare next-generation factories. From the manufacturing management perspective, the chapter refers that “only the agile survive,” although, it mentions that lean manufacturing is also important for supply chain management. The report (chapter) highlights importance of agility to predict and to react to market needs, i.e. flexibility to quickly prepare new products. Another aspect of agility is the necessity to create and re-create relations among manufacturers in order to follow customer needs. The report showed that manufacturers, who implemented agility, recognized two drivers for the transformation to agility in manufacturing: information technology and globalization.

Lean manufacturing is referred twice in the report (chapter). First, as mentioned before, it is important for supply chain management, and second, as an example of how General Motors (GM) learned with Japanese lean manufacturing to improve their (GM’s) performance.

Report: Manufacturing the Future – Federal priorities for manufacturing R&D

In 2008, a forum within the National Science and Technology Council (NSTC), called “Interagency Working Group (IWG) on Manufacturing R&D,” published the report “Manufacturing the Future – Federal priorities for manufacturing R&D” aiming to develop issues related with manufacturing R&D policy, programs, and budget guidance and direction [2]. The outcome of the report established three potential areas for manufacturing R&D: manufacturing R&D for hydrogen technologies, nanomanufacturing, and intelligent and integrated manufacturing.

Of these three areas, the “intelligent and integrated manufacturing” is of the main concern for this review paper. A reference is made to the lean manufacturing as a manufacturing theory and practice that can give benefits to other domains, like services etc. The agile manufacturing is referred as a desirable achievement in the form of agile enterprises and supply chains, and production machines and systems which are easily adaptable and reconfigurable. These achievements are possible through application of advanced software, controls, sensors, networks, and other information technologies.

Regarding the area of manufacturing R&D for hydrogen technologies, the necessity to implement agile manufacturing approach in two challenges for Proton Exchange Membrane (PEM) fuel cells is identified: 1) develop agile, flexible manufacturing, and 2) develop manufacturing and assembly processes for interim production volumes. Development of agile, flexible manufacturing is assumed as a condition in Membrane Electrode Assembly technology due to high costs of changing materials, processes and design. In the development of manufacturing and assembly processes for interim production volumes,agile manufacturing is considered an important pathway for the construction of fuel cell balance of plant and PEM power systems.

International Programs

Seventh Framework Programme (FP7)

The Seventh Framework Programme (FP7) – from 2007 to 2013 – is the European Union’s funding scheme for Research and Technological Development in Europe. FP7 plays a crucial role in EU’s Lisbon Strategy of growth, competitiveness and employment. The objectives of FP7 are grouped into four categories: Cooperation, Ideas, People and Capacities. In the Cooperation category there is a thematic area related to manufacturing R&D, NMP - Nanosciences, nanotechnologies, materials and new production technologies. Annually, in each thematic area a Work Programme is launched.

Since 2007, all NMP Work Programmes refer that production (manufacturing) systems should align to market and to technical aspects, dynamically adapting to resources and processes [4], [5], [6], [8], [9], [10]. To achieve this dynamism, agility in manufacturing systems (agile manufacturing) is an area of research in focus.

Regarding the analysis of agile and lean manufacturing, there are differences between NMP Work Programmes 2007-2008, 2008, 2009, 2010, 2011, 2012. For instance, in NMP Work Programme 2007-2008 the ‘leagility’ concept is present in topic “Beyond lean manufacturing – new industrial models for product and process life cycle” to respond to the increasing demand of customized products [4]. In the topic “Supply chain integration and real-time decision making in non-hierarchical manufacturing networks,” from NMP Work Programme 2008, the capacity to increase European SMEs’ (Small and Medium-sized Enterprises) agility is identified as requirement for them to become globally competitive [5]. Again, the agile manufacturing is mentioned in NMP Work Programme 2009’s topic “Adaptive control systems for responsive factories” [6]. Research of this topic must focus on adaptive control systems for intelligent factories by increasing flexibility and performance of knowledge-based processes and automation towards agile manufacturing operations.

In the NMP Work Programme 2010, out of the two approaches (agile and lean), only lean manufacturing is mentioned [8]. The expected impact of the topic of “Manufacturing systems for 3D-shaped, multi-layered products based on flexible materials” must be a turnkey solution for Original Equipment Manufacturers (OEMs) and SMEs to synchronize their manufacturing with the technological requirements from lean manufacturing systems.

Concerning the NMP Work Programme 2011, the topic of “High tech solutions in the production processes for customised green, safe and healthy consumer products” requires application of agile manufacturing management philosophy [9]. According to the topic, customized products require an increasing interaction with customers to address co-design solutions; and new agile manufacturing processes and new generation of machines, tools and supporting systems are necessary.

Also, in the NMP Work Programme 2012 the agile manufacturing is mentioned [10]. The topic “Intelligent production machines and 'plug-and-produce' devices for the adaptive system integration of automation equipment, robots and other intelligent machines, peripheral devices, smart sensors and industrial IT systems” denotes the increasing importance of agile manufacturing systems in globalized manufacturing due to the requirements for continuous change of processes, products and production volumes. Another topic, “Methodologies and tools for the sustainable, predictive maintenance of production equipment”, demands an agile approach in maintenance. This approach aims to increase the production equipment lifetime and to reduce energy, environmental, and maintenance costs. A reference to lean manufacturing is made in topic “High-performance manufacturing technologies in terms of efficiency (volumes, speed, process capability etc.), robustness and accuracy” [10]. The topic refers that R&D activities should contribute to lean machines and production/manufacturing systems.

The manufacturing management approaches of agile and leanare mentioned not only in “FP7 NMP” Work Programme, but also in “FP7 Cooperation” category of Information and Communication Technologies (ICT). Due to the importance of ICT in manufacturing systems, ICT R&D for manufacturing becomes essential. The ICT Work Programme 2010 yielded an objective called “Smart Factories: ICT for agile and environmentally friendly manufacturing” that focused on integrated process automation and optimization, real-time management of information (energy, material flows, etc.), and other technological solutionssuch as robotics and laser applications, in order to achieve agile manufacturing [7]. The technological aspects of agile manufacturing are based on high levels of intelligence and integration of advanced technologies. Also, sophisticated products development requires agile manufacturers (with agility, flexibility, scalability) and this is referred in the objective “Smart Factories: Energy-aware, agile manufacturing and customisation” [7], of challenge “ICT for the Enterprise and Manufacturing”, in the ICT Work Programme.

4. CONCLUSIONS

Worldwide manufacturing R&D programs aim to increase manufacturing competitiveness. They could be considered as strategic “battle plans” in the manufacturing sector in the worldwide scenario. The competitive behavior creates positive characteristics such as innovation, pro-active and customer oriented attitude etc. However, it could also generate some negative effects, like conflicts, capital oriented attitude andlow ethics.

The first conclusion of this review is that R&D programs approach lean management as a well-known manufacturing approach, with proven examples and it is associated and oriented to efficiency (cost, energy, etc.). There is a general tendency of applying lean manufacturing to services, i.e. to implement lean manufacturing in companies that provide services to manufacturing companies. Another tendency is to integrate OEM lean manufacturing approaches into SMEs, trying to transfer manufacturing best practices from large enterprises to SMEs. Although the programs have references to lean management for supply chain management, the underlined objectives usually are to increase flexibility and responsiveness among enterprises. In fact, by the literature, e.g. see Table 1, these are the properties of agile manufacturing. In other words, agile manufacturing is the real (or better) solution to supply chain management to incorporate the above qualities.

The second conclusion is that agile manufacturing is seen as more pro-active and reactive to customer needs, being considered as customer oriented management approach. Changing processes, products/services and production volume are requirements that are associated to agile manufacturing and are answer for manufacturing companies' internationalization and operation at global scale. An important and very relevant aspect is that some programs claim that agile manufacturing must be implemented in educational programs. The third conclusion is that both the approaches (agile and lean) tend to adopt ICT solutions, although references to agile management emphasize this aspect, highlighting that ICT plays an important role in agile manufacturing.

All in all, lean manufacturing is an approach considered in several R&D programs, however there is a general tendency to drive manufacturing stakeholders to adopt agile manufacturing, being considered as a path to sustainable manufacturing industry.

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"FROM MANAGEMENT SYSTEMS (9K, 14K, 18K) TO RS (26K): ITS INFLUENCE IN RISK MANAGEMENT AND CONSEQUENT COMPETITIVENESS FACTORS OF THE ORGANIZATIONS THAT ADOPTS THEM ".

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Keywords: Social Responsability, Risk Management, Management systems, Sustainability.

INTRODUCTION

Creating a corporate environment in which the interests and concerns of the several players are preserved is without a doubt the great challenge of the Social Responsibility practices.

The activity of the organizations creates positive and negative impacts on the economic, social and environmental levels, at a global scale.

In the globalisation context, the organizations can exist under the jurisdiction of several laws in different states. The organizations identity, along with the diversity of legal requirements, drove the public opinion to a higher demand on its performance, with the intent of adopting socially responsible practices that are beyond the local legal context.

This guidelines motivated the development of the project of the ISO 26000 International Norm [1], starting in 2004. To apply this norm, social responsibility is seen as "the responsibility of an organization for the impacts of their decisions and activities in the society and environment, through an ethical and transparent behaviour that:

- Contributes to sustainable development, including health and well-being of society;
- Take into account the expectations of all the interested parts;
- Is in conformity with the law and consistent with international conduct norms;
- Is integrated in the entire organization and practised in its relations."

This process should be conducted with a consistent and sustained dialogue with the interested parts that the organization consider to be relevant, and should focus on environmental, economic and social aspects of general interest, and not in aspects of particular interest or specific to just one interested part, with the aim of continuously improving its performance.

The Social Responsibility thematic has been progressively gaining visibility and notoriety a bit throughout the world, and even if it's not a new thing, the present conjuncture has given it bigger relevance. The definition of clearer functioning and decision making rules and risk [2] management and control got under the scrutinizing eyes of the business environment, investors, media and public opinion.

In this context, Risk Management is part of the Social Responsibility system [3] inside an organization. It's about getting the probability of risk events, based in qualitative provisions and/or quantitative statistical and economic calculations, with bigger possibility of and unexpected event, with the aim of reducing, transfer or share damages from possible corporate "disasters" or transform them into new business opportunities.

The identification of corporate risks [4] tends to avoid or prevent unfavourable situations to the corporation in advance, allowing to establish an effective modelling process of calculated risk management, aiming the continuity of the business and the perennity of the organization.

The Social Responsibility is associated to the development of better organizational practices and to the search of a better dynamic in its development, which should allow the companies to increase efficiency, reduce and control risks and, therefore, a better sustainable performance.

THE INFLUENCE OF RS IN RISK MANAGEMENT AND CONSEQUENT COMPETITIVENESS FACTORS OF THE ORGANIZATIONS THAT ADOPT THEM

This documents aims to analyse the Social Responsibility mode, according to the concepts of ISO 26000 and its integration with the [6] Quality management systems (ISO 9001), Environmental management systems (ISO 14001), Occupational Health and Safety management systems (OHSAS 18001) relating this subject with the risk management performed in the companies. In what way can the adoption of this model affect the risk management, resulting in a better, or worse, company sustainability?

What is the influence of the Social Responsibility models, adopted by the organizations, in the risk management, seen in the achieved sustainable performance?

In scheme, the problem in study is focused in the following relation: Dialogue with stakeholders / risk management / Social Responsibility / Sustainable Performance.

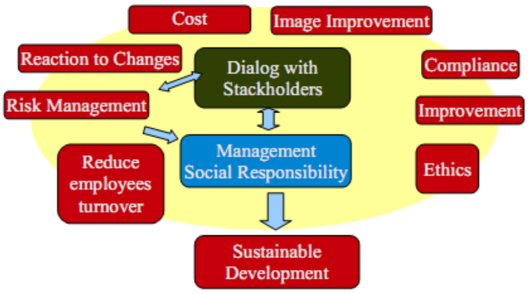

Fig. 1. : Dialogue with stakeholders / risk management / Social Responsibility / Sustainable Performance

MANAGEMENT SYSTEMS (9K, 14K, 18K) AND RISK MANAGEMENT

For decades, the top organizations have developed and implemented measures close to Risk Management, frequently under the flag of Quality Management projects. The used methodologies have a very specific vocabulary, with own terms, many times hard to relate with the present terms of the Risk Management glossary. The techniques were integrated in the processes of product and processes conception control, but today are supporting the implementation of environmental management systems, people safety management, information safety e also certain industries of high risk level (pharmaceutical, food, etc.). Due to this, some Quality professionals got a significant experience in the use of systems integration and methodologies, specially in the car, aviation and electronics industries.

In the last years there have been growing concerns and new priorities, such as Environment, People Safety and Society. As a result, some of the best practices of the organizations gave birth to new international norms and new certifications. Social Responsibility and Governance will become critical aspects of organizations, specially after recent scandals.

As mentioned before, Quality has been associated to important planning tools.

The Advanced Quality Planning is based simultaneously in Planning and in Risk Management. The process predicts the necessary steps to minimize the risks involved with the launching of new products e processes. The Advanced Quality Planning integrates several good practices, such as the Project Revisions, the Processes Capacity calculation and the measuring systems evaluation.

The requirements of the ISO 9001:2008 norm are, mostly, intimately connected to Prevention and Risk Management. For instance, if analysing the necessary guarantees to a Civil Responsibility Program of Product X, coincident aspects would be indicated with mostly all requirements of the norm:

- Contracts and Agreements
- Product Project Guarantees
- Publicity and Marketing Communication
- Reliability and Tests
- Labels and Instructions
- Records
- Suppliers
- Product guarantees, conditions and collection procedures
- Procedures related to incidents and accidents investigation
- Disputes Management

Some reasonings of this type and this global vision on [5] Quality can be found described in many models of Social Responsibility. If the organizations choose to use this measures, many other topics can be addressed and implemented with a certain degree of integration in Environmental Management, Risk Management, Knowledge Management, Ethical Codes, the use of new statistics and the growth of employees autonomy and participation.

The best practices of the top organizations end up as contents of some international norm, usually published by ISO. This process was finally addressed with the ISO 2600 norm, congregating the rising concern with the stakeholders involvement.

The implementation of approximation by Processes is a fundamental condition to the existence of Strategical Planning and Risk Management effective/efficient processes, as an answer to several important requirements:

- The necessity to define the several responsibilities involved in Risk Management;

- The capacity to define and report the several elements of Risk Management;
- The involvement of all employees in Risk Management.

The most critical risks identified at the level of the process should go up to the management level, namely as an entrance in the Strategical Planning (and vice versa). The Strategic Risk is defined as “the risk associated to the organization plans and strategies”.

Though many organizations prepare an annual Strategic Plan, most of them forgets one of its more important steps: Strategic Revision. The existence of this periodic activity, involving different representatives of the several organization sectors, is fundamental to control the identified risks e to follow the preventive actions. This activity, management revision, its in fact required by the management systems norms (ISO 9001, ISO 14001 and OHSAS 18001), that gets strengthened with an integrated quality, environment and safety system . The Strategic Revision plays a fundamental part in the Corporate Risk Management.

The professionals of the management systems get involved in projects that involve the implementation of the respective norms and models. This norms require a certain type of Strategic Planning and Risk Management. Thus, during its implementation, it is frequent to have the necessity to change or improve some aspects of Risk Management.

The table shows the big amount of relations that exists between Risk Management typical tasks and the Quality, Environment and Safety norms implementation projects, among others.

Risk Managment Tasks	Tipical Quality Projects					
	ISO 9001 *Quality*	EFQM *Excel. Award*	GRI *Social Resp.*	ISO 14001 *Environment*	ISO 27001 *Safety*	OSHAS 18001 *Safety*
Risk Norms Adoption			□	■	■	■
Risk Management Implementation	□	■	■	■	■	■
Management Revision Implementation	■	■	□	■	■	■
Internal Audits Implementation	■	■		■	■	■
Critical procedures definition	■	■		■	■	■
Approximation by Processes Implementation	■	■		□	□	□
Risk Analysis Preparation	□	□	■	■	■	■
Risk Integration and Aggregation		□	■			
Legislation Control	□	□	■	■	■	■
Improvement Processes Implementation	■	■	■	■	■	■
Prevention Tools Introduction		■		■	■	■
Product/Service Responsibility	■	■	■	■		■
Business Continuity	□	□	□	■	■	■

Fig 2: Relations between Risk Management tasks and norms implementation projects.

Risk Management and the Management of respective management systems involve essentially preventive activities that are part of the organizations culture and try to anticipate and prepare the future. We can conclude that the organizations that implements Social Responsibility and Quality, Environment and Safety management systems can have a better performance when compared to the Risk Management practices, specially concerning the integration of similar requirements from several norms, and in this way obtain more sustainable performances against other competitor practices.

CONCLUSION

The analysis of all theory and practice related to the references and management, already commonly used (ISO 9001, ISO 14001 e OHSAS 18001), leave a solid support to infer that the **organizations with better RS practices**, according to the requirements of the respective Management systems (ISO 9001, ISO 14001 e OHSAS 18001), have fewer risks in the perception of less favourable situations at the business sustainability level, that is, a **more effective risk management**, reflected in a **better sustainability**.

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STAKEHOLDER SATISFACTION AND SUSTAINABLE SUCCESS

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Abstract: The relationship between Stakeholder Satisfaction and Organizational Sustainable Growth and Success is investigated focusing on the importance of a firm's relationships with critical stakeholders that may lead to better performance, as organizations while integrating business and societal considerations create value for their stakeholders.

Framed on Stakeholder Theory an online survey was administered to Managers of Portuguese organizations with certified management systems by APCER. The findings suggest that Competitive position is strongly correlated with Shareholders, Suppliers and Partners, Employees and Customers satisfaction, legitimating Freemans Stakeholder Theory.

In an overall final remark, the importance of Shareholders, Partners/Suppliers, Employees and Customers satisfaction for organisational Sustainable Success is highlighted in this study results.

Keywords: Organisations, Stakeholder Theory, Sustainable growth

INTRODUCTION

The issue of whether there is a link between Corporate Social Performance/Stakeholder Satisfaction and Corporate Financial Performance/Organizational Sustained Success remains the most controversial area in the business-in-society field (Barnett, 2007).

In recent years Corporate Social Responsibility has become a relevant concept that frames the business contributions to sustainability (Commission of the European Communities, 2002). Although there is no consensus concerning the concept of CSR (nature, motivations, impacts) and the results of the research, literature review allow us to conclude that most definitions take into consideration a economical, social and environmental dimensions (Hediger, 2006).

Scholars within the neoclassical economics tradition argued theoretically that Corporate Social Responsibility strategies unnecessarily increase firm's costs therefore creating a competitive disadvantage compared to competitors((most notably Friedman, 1970).

However, many other scholars have argued that companies that satisfy the expectations of their stakeholders have higher economic benefits than competitors and achieve positive differentiation (Hilman and Keim, 2001, Berrone, Surroca and Tribó, 2007). According to other studies, improved social performance may also lead to positive effect on Employees (Brammer, Millington and Rayton, 2005; Ahamad, O´Regan and Ghobadian, 2003) and Customers (Folkes and Kramins, 1999; Maigan et al. , 1999; Crever and Ross, 1997).

Previous studies researching the impact of Social Responsibility and financial performance have achieved mixed results, pointing to a positive relationship (Margolis and Walsh, 2001) but have to be analyzed carefully due to potential methodological concerns ((McWillams, Siegel e Wright 2006; Margolis and Walsh 2001).

In this work, we try to investigate if Stakeholder Satisfaction can contribute to the sustained growth and success of Organizations (ability to achieve and maintain their objectives in the long term), by consistently meeting the needs and expectations of the interested parties, in a balanced way, over the long term (ISO 9004:2009).

THEORETICAL FRAMEWORK

Stakeholder theory (Freeman, 1984) is the main theory supporting the business case for the Satisfaction of the Organizations Stakeholders by focusing on the importance of a firm's relationships with critical stakeholders that may lead to better performance, as organizations that integrate business and societal considerations create value for their stakeholders.

Another theoretical approach that can support this argument is the Resourced Based View of the Firm (Barney, 1991; MacWillims and Siegal, 2001) by advancing that if the organizational resources and capabilities of a firm are valuable, rare, inimitable and nonsubstitutable, they will translate into competitive advantages that can in turn generate operational results and generate sustainable value. But in order to achieve sustainable competitive advantage, an organisation must assure the satisfaction of all relevant stakeholders.

CONCEPTUAL MODEL AND RESEARCH HYPOTESES

Building on literature and managerial contribution, the following Conceptual Model and Research Hypotheses have been proposed to be empirically tested:

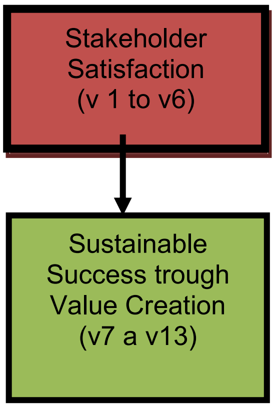

Table1 - Research Question

H1	Stakeholders Satisfaction has a positive relation with Sustainable Success

METHOD

Sampling frame consisted of Quality, Environmental and/or Safety Managers of organizations with Management Systems certified by APCER (www.apcer.pt). Of the 2906 Managers contacted by email, 375 responses were received (with 204 full complete responses).

INSTRUMENT

A self-administered on line questionnaire was used (Lime Survey). Following literature review and managerial contributions an exploratory study was performed with key Quality, Environmental and Safety and Sustainability Managers. A pre test of the questionnaire was made and the respondents were contacted by email to fulfil the final questionnaire via web.

RESULTS

Stakeholder Satisfaction is the independent variable (with 6 dimensions, v1 to v6) and Sustainable Success s the dependent one, composed with 8 dimensions (v7 to v14). All variables were measured with a 1 to 7 Likert scale and construct reliability was tested with Cronbrach Alpha.

Table 2 - Correlation coefficients

Correlations (Spearman's rho)	V1	V2	V3	V4	V5	V6
V7	,387 **	,487 **	,550 **	,469 **	,357 **	,415 **
V8	,275 **	,394 **	,510 **	,327 **	,232 **	,338 **
V9	,327 **	,400 **	,430 **	,451 **	,332 **	,393 **
V10	,309 **	,390 **	,477 **	,398 **	,257 **	,367 **
V11	,288 **	,404 **	,421 **	,406 **	,221 **	,298 **
V12	,321 **	,436 **	,474 **	,398 **	,258 **	,291 **
V13	,423 **	,485 **	,544 **	,518 **	,345 **	,345 **

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3 - Legend

V1	Customer Satisfaction has continuously increased over last 3 years
V2	Employees satisfaction has continuously increased over last 3 years
V3	Shareholders satisfaction has continuously increased over last 3 years
V4	Quality of Suppliers and Partners relationship has continuously improved over last 3 years
V5	Relationship with Community and Society has continuously improved over last 3 years
V6	Relationship with Authorities has continuously improved over last 3 years
V7	Our Profitability has increased over the last 3 years
V8	Our Profitability is very positive
V9	Our Profitability should continue to increase over the next 3 years

V10	Our Revenues have grown over the last 3 years
V11	Our cost reduction results have improved over the last 3 years
V12	Our results to catch new customers have improved over the last 3 years
V13	Our competitive position has increased over the last 3 years

DISCUSSIONS AND CONCLUSIONS

As is illustrated in Table 2, all the results show a positive medium to moderate correlation between Stakeholder Satisfaction and Sustainable Success (correlations are significant at the 0.01 level (2-tailed).

Concerning Profitability, Shareholders Satisfaction, Employees Satisfaction and Quality of Suppliers and Partners relationships show the highest correlations.

As for Revenues increase it is noted that Shareholder Satisfaction has the highest correlation leading to the question of what is the cause and effect relationship. Quality of Suppliers and Partners, Employees satisfaction and Customer satisfaction are also relevant.

Cost reduction show a strong correlation with Shareholder Satisfaction, Employee Satisfaction and Quality of Suppliers and Partners relationship. While it might be argued that Stakeholders are pleased with cost reductions, we can also argue that satisfied Employees, Suppliers and Partners are eager to work more lean and efficient.

New Customers seem to be best attracted by Satisfied Employees, Shareholders and Best run Suppliers and Partners.

Finally, Competitive position is strongly correlated to organizational relevant Stakeholders Satisfaction, mainly Shareholders, Suppliers and Partners, Employees and Customers, legitimating Freemans Stakeholder Theory.

In an overall final remark, the importance of Shareholders, Partners/Suppliers, Employees and Customers satisfaction for organisational Sustainable Success is highlighted in this study results.

THEORETICAL AND PRACTICAL CONTRIBUTIONS

In this work we find evidence that according to a large number of Portuguese managers that belong to organizations with a certified management system, stakeholder satisfaction is relevant for the organizational sustainable success. as suggested by Freeman (1984) Stakeholder theory. This work also has relevant contributions for management practice highlighting the importance of Shareholders, Employees and Partners/Suppliers satisfaction for Sustainable Success.

LIMITATIONS AND SUGGESTIONS FOR FUTURE WORK

One of the research limitations of this works is that the respondents were Managers from organizations with a certified management system from APCER and the analysis is based on their perceptions. Additional research should extend this study to certified organizations by other Certification Bodies and also with non certified organizations. In addition it might be useful to replicate the study with Managers from other countries.

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AN USER-DRIVEN APPROACH FOR SERVICE PROCESS INNOVATION

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Abstract: The nature of innovation is changing. An increasingly globalized society, enabled by information and communication technologies (ICT), has changed the process of value creation and shifted the balance of power between firms and individual consumers or users. Today, companies must also find ways to define and deliver unique experiences, together with users, in order to survive. However, this requires a paradigm shift in terms of mindset and adjustments to current working practices. This paper gives an overview of the role of ICT technologies in the co-production between supplier and user. Additionally, the most important aspects in the area of knowledge creation and innovation through knowledge networks were analyzed. Finally, six innovation policies based in ICT technologies were proposed in order to allow an easier integration of user knowledge in the companies' knowledge networks.

Keywords: innovation, customer_relationship, collaborative_communication, information_services, knowledge_driven_organization.

INTRODUCTION

In the 80's and 90's, the companies focus was primarily on the supply of new research and technology as the key driver of innovation [1]. National innovation strategies aimed at increasing R&D investments, particularly in "high-tech" industries. Simultaneously, companies aimed at developing the most technologically and advanced products and services.

In recent years, however, more focus has been given to the innovation driven by user's needs and requirements. With increased global competition and cheaper sources of high-quality technological solutions, companies can no longer rely on maintaining a competitive advantage based on "traditional" drivers of price and quality. Companies must strive to seek alternative sources of competitive advantage and are, therefore, undertaking major transformation in their innovation processes and business models in order to deliver more valuable products and services to the market. These new innovation strategies often involve increasingly open business models, a great focus on understanding latent consumer needs, and more direct involvements of users in various stages of the innovation process.

This paper explores the role of customers in service process innovation. Initially, we analyse the co-production model between service supplier and customer giving a particular emphasis to the process of knowledge creation and IT tools that support this collaboration model. Then, we identified several customer roles and integration stages in the business service production. Also, some international cases of user-driven successful innovations are shown in this section. Finally, we suggest some user-driven innovation policies that could help to increase the participation of citizens in the innovation process.

CO-PRODUCTION BETWEEN SERVICE SUPPLIER AND CUSTOMER

The idea of customer value as a phenomenological experience by a customer is well established in consumer research [2]. In particular, Morris Holbrook has made important contributions in this field. He defines customer value as an *interactive relativistic preference*. However, Holbrook's work is mainly in the field of consumer research, his conceptualism of customer value is relevant to any type of customer and interaction. Holbrook defines *interaction* as a relationship between some subject (customer) and some object (e.g., product, service, event, social cause, innovative idea). In service context, a customer interacts with the outcome of the service, as well as with the service provider's employees or physical resources during the service delivery process.

In recent year, Payne et. al [3] proposed a conceptual framework focusing on processes that emphasize the development of relationships between customers and suppliers through interaction and dialog that places the customer explicitly at the same level of importance as the company: as co-creators of value. They explored three main vectors in the framework. The first, related with the customer, deals with the processes, resources and practices which customers use to manage their activities. The second, related with the supplier, deals with the processes, resources and practices the supplier uses to manage his business and his relationships with stakeholders, customers included. Finally, the "*encounter processes*" deals with the interaction and exchange that take place within customer and supplier relationships. It is precisely the last which needs to be managed in order to value creation [3]. This approach, can face some difficulties in some business contexts, however it suggests an advanced view of the alignment customer-supplier in co-creation value.

In fact, customer value is hence tied to a customer's meaning attached to the experience with a service [4]. In a business context, meanings are tied to economic and other organizational consequences and goals. However, it is clear that when a number of individuals are involved, alongside shared organizational meanings, other more individual meanings are being attached to both the service process and its outcome, and thus influence experienced value of services being used. Furthermore, the fact that customers themselves are involved in the service process influences their assessment of service outcomes.

Supporting the Process of Knowledge Creation

The knowledge is the most important organizational resource in the "knowledge society" [5]. Knowledge creation is the process which produces new knowledge and innovations. The stages of effective knowledge management can be described as follows:

1. Identifying knowledge;
2. Creation of new knowledge;
3. Building of competences;
4. Effective management of innovation.

Fostering the process of knowledge creation is the first step to facilitating innovations in the company. In fact, the organizational form of a Knowledge Network is the appropriate form to enable knowledge creation, and by doing so, foster innovation. Different activities can foster or enable the process of knowledge with Knowledge Networks. Knowledge Network as organization form is itself enabler of knowledge creation. This organizational form enables the company (e.g., to combine and involve different knowledge resources like customer, competitors or research centers. By doing so the network crosses organizational boundaries and builds the appropriate environment for creating new knowledge.

The Figure 1 summarises the important aspects in the area of knowledge creation and innovation through Knowledge Networks.

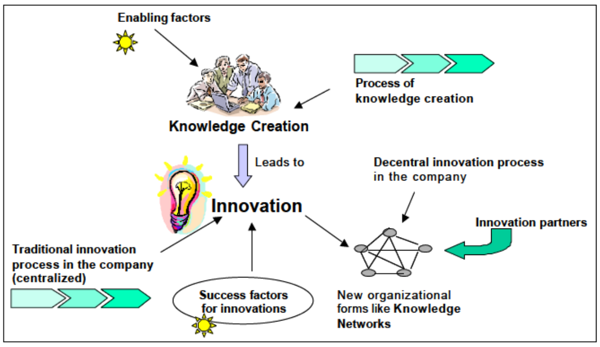

Fig. 1. Inter-connection concepts between knowledge creation and innovation [6]

The great value of Knowledge Networks is in facilitating innovations through the network structure. The network structure enables the company to integrate other innovation partner in the innovation process.

To companies that focus on costumers' knowledge creation to lead innovation, a new proverbial concept makes sense when we think about Customer Knowledge Management (CKM): "'*if we only knew what our customers know*" [7]. CKM is a strategic process that enables customers to move from a passive attitude towards a simple service or product that brings them benefits to active knowledge contributors' partners. Combining the concept of the knowledge management (KM) and the concept of the Customer Relationship Management (CRM), we may say that CKM extends both to a level where costumers are seen by companies as active elements capable of creating value by themselves.

Eriksson et al. [8], presents an emerging concept named "*Living Labs*" as systemic innovation approach that contributes to the deployment of ICT solutions involving communities of users, consumers or citizens.

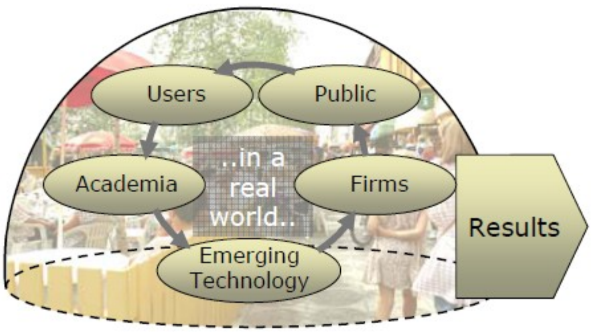

Fig. 2. Basic "Living Labs" Concept [8]

This concept, depicted in Figure 2, is based on a human-centric approach that conceives human beings, as citizens and the civic society, as a source of innovation and not just as users or consumers in a narrow sense (they are no longer just objects for R&D activities). According to this model, innovation is introduced and validated in collaborative context real-world environments. The individual is in focus in the role of a citizen, user, consumer, or worker. The given results emerge from a collaborative network [8].

Role of ICT Tools in Cooperation

Ideally, the chosen interaction channel must be connected to the objectives of user involvement and the role that users have in the development. Traditionally direct user involvement (e.g., workshops) is more often chosen when the objective is to create ideas and indirect user involvement (e.g., surveys) is more likely favoured when the emphasis is on testing already designed ideas.

The appearance of Internet, particularly Web 2.0 technologies, created the opportunity for employees and users to give their opinion about design and proposals. Some popular techniques include electronic message board, chat-lines, forums and newsgroups. In all cases, it is crucial to have knowledgeable people responding to the questions and problems raised. It has to be really interactive and not just a gadget, because if users are asked for their opinion, something has to be done with it [9].

Currently, online involvement and virtual communities are blurring the line between direct and indirect interaction, and a great proportion of recent literature on designing customer involvement concentrates on online involvement and virtual communities. With the appearance of new ICT solutions, especially social media, consumers can make more in-formed decisions, posses a global view of matters and network with others. This all facilitates consumers to experiment with and develop new products and service ideas [10]. Understanding users as value co-creators and sources of innovation not only points to users' ability to innovate themselves but also draws attention to new forms of collective organization and collaborative practices that make possible collective and distributed innovation [11].

Sawhney et al. [12] have listed some characteristics of the Internet as a platform for customer involvement. Benefits include the direction of communication (dialogue instead of one way), intensity of communication (continuous interaction instead of on the spot), richness of communication (social knowledge instead of individual) and size and scope of audience (also mediated interaction with both current and prospective customers). Also Fuller and Matzler [13] argue for the benefits of virtual customer environments. Because products can be presented in virtual environments, the customers have a better foundation for innovating and the quality of ideas should also enhance.

Sawhney et al. [12] categorize virtual techniques of customer collaboration by the nature of collaboration and by the stage of product development process (Figure 3). One phenomenon around virtual user involvement is the emergence of autonomous web-based innovation marketplaces.

	Frontend (ideation and concept)	**Backend (product design and testing)**
Deep / High richness	Suggestion box; Advisory panels; Virtual communities.	Open-source mechanisms; Web-based patent markets.
Broad / High reach	Online survey; Market intelligence services.	Web-based prototyping; Virtual product/market testing

Fig. 3. Virtual customer involvement techniques [12]

Some International Cases

There are several great examples of large international companies with in-house departments that focus exclusively on the mapping and assessment of user needs. Moreover, there are also examples of small and large companies working with private consulting companies in driving innovation projects built on systematic user surveys. Universities and knowledge centers also often participate in the user-innovation process as well.

Two companies were identified due to their relevance and successful innovation projects launched in the market during previous years. These identified companies that will be presented in the scope of this paper are Gap and Marks&Spencer.

Gap is one of the world's largest fashion companies. A few years ago Gap launched a consumer insights unit aimed at establishing a better platform for brand and product development as well as searching for new ideas and opportunities that could drive sales and profits.

Consumer Insight employees have an interdisciplinary background in social sciences and their main task is to generate knowledge on customer experiences that can be integrated into company strategies and core processes.

Knowledge on user needs and experiences support design development and price-quality relations, but also brand positioning and loyalty programmers. The department focuses on how customers behave when shopping, what constitutes the ideal experience, and how this knowledge is applied when designing stores [14].

Marks&Spencer is another good example of user-innovation strategy. The company is among Britain's largest retails companies. Its main activities are clothing, foods, furniture and financial services.

An important tool in the innovation process is the Trend Prediction department that collect consumer data and inspiration for the company's design units. The Trend Prediction employees include designers and people from social sciences. Trend Prediction works closely with Marks & Spencer design team throughout the design process and suppliers designers with useful data on culture and fashion trends [14].

USER-DRIVEN INNOVATION POLICIES

Mobilizing the power of consumer innovation can bring huge gains to business and the economy. Companies can learn to work more effectively with user innovation and use some advanced methods and IT technologies to allow an easier integration of the user knowledge into the internal company boundaries. Some ideas and proposes are presented in the section bellows.

At the same time, it is important to consider that the government has an important role in the promotion of a user-innovation culture. A public policy for user-innovation should focus on elements such as reduce the risks of innovation, provide competition for monopolies, promote social inclusion and innovation, promote an intellectual property regime.

Identify lead-users groups

Lead users tend to have more extreme and intensely felt needs which put them at the leading edge of change in a field. Lead users often have greater knowledge, they use products more intensively and they have skills that allow them to adapt products. Lead users innovations tended to be more novel, had longer-term potential and, five years after their creation, had sales seven times higher than traditional innovations.

Successful organizations also draw on lead users within their own ranks. Sibelius produces software for composers to translate music into a score, which they can then orchestrate. Around 90 per cent of Sibeliu's software developers are serious musicians, which allows staff time off to go on tour. Sibelius has narrowed the gap between the users and the producers that so bedevils innovation, because, in this instance, the producers are themselves lead users.

Remove barriers to user-innovation

Removing the barriers to user-innovation is also critical. Users will be put off if contributing their ideas is difficult or time consuming. However, we can see already a great example of user contribution in the Open Source software. In fact, Open Source software is one of the most important and inspiring movement in technology. It is responsible for a great deal of innovation and democratization of the internet and beyond.

The most important process in any open project is contributions management. From the way in which a contribution is made, through how it is discussed, approved or rejected, to how it is applied to the final product, the process dictates everything else. Any discussion about creating collaborative specifications or software must start from contributions management – otherwise, it is lacking the most important tool needed to produce a successful end result. In most Open Source software programmes 80 percent of the participants generate at most 20 per cent of the contributions. Yet these small contributions, such as reporting a bug in a system, often trigger larger innovations.

Making it easy for users to contribute needs to be combined with processes to ensure quality. A good example is the Wikipedia. Typically, Wiki applications facilitate a case where social relationships are established over a domain of social actions such as acceptance, objection or rejection of a contribution. Moreover, as in the case of Wikipedia, the Wiki facilitates a collaborative document editing effort relying on the contribution of multiple authors in a concurrent system that would be able to combine the contributions in an effective and democratic way. From a social research point of view what makes such a case interesting is the negotiation process that takes place when writing and structuring the article. For example a user makes a contribution which is erased and this user tries to establish its contribution back (to make it visible and accepted by the others). In both cases (article and negotiation) there are interaction ties which characterize the final outcome and the dynamics of the process.

Incentive user-innovation

Some innovators are motivated by financial rewards: computer games companies are experimenting with rewarding player-developers who create successful modifications. Yet most user-innovators seem to be motivated by the recognition they get for their achievements. Providing a way for user-innovators to publish their innovations and have them rated by other users create a way for people to gain acknowledgment from their peers.

It is possible to see a similar approach of recognition in the Open Source software community. Lakhani and Von Hippel [15] list three types of incentives that can drive a firm to participate in open source software development: direct utility to the organization from collaborative, early access to technology and new technological trends, and intrinsic benefit from participating in the development of this software, such as learning a new skill and signalling one's abilities in a technological arena to peers or others.

Provide easy-to-use tools for innovation

Users need different kind of tools to start innovating and they may not have all of those at their disposal. In many settings, it may make sense for suppliers and manufacturers to abandon costly attempts to understand what consumers want and simply give people easy-to-use, low-cost tools so they can sort it out for themselves.

Currently, some users will want to go further and modify products and services themselves. That requires another set of immersive and interactive tools. In computer games these tools include the source code for the games and software development tools to allow players and developers to fiddle with code.

The steam community is a good example. The company provides a Software Development Kit (SDK) to some of the game engines that they have on their online store and a marketplace where developers can submit their products and users can test it or buy it. Starting from the engine of a given game, users develop their own "*mod's*". Those "*mod's*" that get more successful among the community, usually, become a commercial steam product. For example: Thanks to a community of users, the first version of Counter-Strike started as a free "*mod*" that ran over a game named "Half-Life". Nowadays, Counter-Strike is no longer a "*mod*". It has become in a commercial steam game that has several versions.

Another example is Nike plus. The company has combined web and mobile technologies, such as iPod, that allow user interaction with supporters while running. In one hand, Nike gets feedback about its own products from the community of Nike users. On the other hand, they collect user's experience from its fans and from user supporters. It is also known other successful examples when the company start by offering the opportunity to users to create their custom sneakers using web based technology [3].

Create user-test frameworks

Innovation is not just about coming up with ideas. It involves prototyping, testing and refining tools.

A limitation of many user-design tools is that they do not allow for this kind of trialling and testing. One can design a computer online by fitting together various modules but it is very difficult to test out how well it will work until you get the computer home, by which time it might be too late.

Encourage user innovation also entails encouraging users to take risks and make mistakes. That may be acceptable when mistakes are not costly and can be easily corrected (e.g., a piece of software can be rewritten, a ring tone deleted). But it will be less acceptable if the mistake cannot be easily undone (e.g., risks of safety). Companies also need to exercise caution in encouraging consumers to take excessive and unjustified risks.

Create support communities

Most innovation is essentially collaborative [16]. That particularly applies to user-innovation, where communities are vital to user innovation, because they stimulate ideas through imitation and competition; encourage users to build upon one another's ideas, bringing together many small ideas to have a big impact; provide user-developers with an audience from who they can gain recognition and standing; help to spread good ideas fast and, through peer review, weed out bad ideas.

Communities are the best way to recruit new participants, who are more likely to join in if they are introduced by a friend rather than in response to an advertisement or company campaign. Communities and networks are the basic building blocks for word-of-mouth marketing for products and the main means to spread user-generated ideas.

An organization can help to create an innovation community around a product or service but it cannot dominate it, run it or own it. Communities need tactful, light touch leadership. They need not to be seen as a joint venture, between an organization and the community that forms around its product or service. Companies seeking to create communities of user-innovators around their products should learn lessons from other companies such as Google.

Google seemed to have understood that when they created the Android community. Basically it consists in a triangle relation between the industry, the developers and the users. Industry offers open-source environment. Developers can create, extend, or update applications, by submitting them to a marketplace where users can buy or experiment. Users can submit feedback about a product, receive notifications about updates and experiment new products, with the benefit of being part of a trustworthy community. As evidence, we have the increasing success of the Android operative system and its overall environment market.

CONCLUSIONS

In today's competitive business market, one promising way to support market success is innovations originating from the customers' needs. Service orientation in business changes the connection to the customers. The service and its tangible elements together create the overall customer experience. This requires a firm connection to the customer and ways to monitor customer experiences. Service providers need to know their customers better and offer them better possibilities to be involved in service development.

The ICT market offers a set of new technological possibilities that can enable and foster innovations in service sector. Such technologies innovate both the service development process and the design phases. ICT technologies, particularly Web 2.0 platforms, have a fundamental role in the value co-production activities carried out by both service providers and customers. In fact, collaborative technologies play an important role in services focusing on knowledge and information management because they promote customer involvement and foster knowledge sharing.

Companies should establish and adopt some innovation policies based in ICT technologies to allow an easier integration of user knowledge in their knowledge networks. We propose six innovation policies that a company must adopt, namely the identification of lead-user groups, removing of user-innovation barriers, creation of incentives for user-innovation, providing of easy-to-use tools, creation of user-test frameworks and creation of support communities.

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CUSTOMER-ORIENTED AND ECO-FRIENDLY NETWORKS FOR HEALTH FASHIONABLE GOODS – THE CORENET SUSTAINABLE APPROACH

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Abstract: Consumer needs and expectations of specific target groups - such as elderly, obese, disabled, or diabetic persons- are arising as challenging opportunities for European companies which are asked to supply small series of functional and fashionable goods of high quality, affordable price and eco-compatible. In order to design, develop, produce and distribute such products, a new framework and related components of collaborative networking need to be developed, enabling the product to stay as long as digital to produce on-demand. Market also demands a broader evaluation of the whole product life like sustainability of the production process, healthfulness of the product components and materials, ecological respect and ethical codes. The CoReNet project aims to address these research areas namely the development of consumer integrated collaborative eco-oriented design, the overall integration and co-ordination of business processes and information exchange by a set of new (web)services for network design and the implementation of mechanisms for tracking and tracing of ecology and sustainability purposes.

Keywords: Collaborative Networks; Supply Chain; Business Sustainability, Life Cycle Assessment

INTRODUCTION

The pace and scale of today's globalisation is without precedent and is increasingly associated with the rapid emergence of complex supply chains as production processes adopt collaborative strategies addressing the small series production of high-customized complex products. This is particularly relevant for health fashionable goods for specific target groups that are incrementing their relevance in the market. In fact, consumer needs and expectations of specific target groups - such as elderly, obese, disabled, or diabetic persons- are arising as challenging opportunities for European companies which are asked to supply small series of innovative and fashionable goods of high quality, affordable price and eco-compatible.

In particular in two sectors: Textile and Clothing Industry & Leather and Footwear Industry, the number of seasonal collections has been increasingly enlarging the offer in terms of models along the year, and the number of sold products is decreasing in major markets, leaving best opportunities only for value added products in the perception of the customers. In reality, consumers are increasingly demanding for personalization and value adding of harmonized products in the Textile, Clothing and Footwear Industry (TCFI), not only in terms of aesthetics, but also in terms of health, innovative functionalities and environmental impact.

Consumers want to know where the product comes from, how it has been created and how it will satisfy his needs and provide health and well being now and for future generations. In order to design, develop, produce and distribute such products, a new framework and related components of collaborative networking are need to be developed, enabling the product to stay as long as possible digital to produce on-demand.

Research is necessary in many topics like: a) consumer integrated collaborative eco-oriented design, b) full adoption of Rapid Manufacturing and Business Intelligence technologies; and c) the overall integration and co-ordination of business processes and information exchange by a set of new (web)services for network design and ad-hoc (re-)configuration, for real-time planning, and for tracking and tracing of ecology and quality.

This paper addresses the multidisciplinary complexity of customer-oriented and eco-friendly networks for health fashionable goods in particular concerning main collaborative business sustainable processes tailored on customized environment as well as able to respond to the high variability of the consumers demand and expectations.

FRAMEWORKS FOR SUSTAINABLE NETWORKS

A new level of complexity is arising, given the fact that competition as well as collaboration schemes are transitioning from between companies to between supply networks. In consequence, management of both inter-organizational and inter-supply chain processes and information is becoming even more critical for rapid response, eco-sustainability and quality assurance of products and processes especially when production involves small series.

Recent research in the field addressed different forms of business networks. They are distinguished for example by value chain orientation (horizontal, vertical, lateral), life span (long-term vs. short-term), degree of virtualization or hierarchical structure (hierarchical vs. non-hierarchical networks) [1]. And yet, most tangible business networks are formed along the value chain and for enduring purposes. Nevertheless, the current market asks for flexible organizational structures which can quickly adapt to new business requirements and sustainability challenges. This new demands are forcing business networks to have much shorter life-time existence and take advantage of new infrastructure technologies supported in distributed information systems and knowledge.

The new paradigm of demand-driven supply networks is emerging in literature as a collaborative approach in response to consumers needs and expectations [2][3]. This implies different approaches to the market based not only on traditional sales channels (shops, retailers) but more and more on an Internet mediated direct contact with consumers both for product conception and for product sales.

At the same time, the market increasingly values collaborative networks that endorse the sustainability challenges. These networks by seeing the world's present and future challenges seek to develop new products and processes that can be part of the solution.

From the production viewpoint, companies from different sectors in sustainable networks need to integrate their production systems in order to offer to the customer integrated solutions and innovative services and products. Collaboration will not only be regarded under the aspect of organizational networking, but also under terms of business sustainability, knowledge networking and ICT networking to achieve strategic goals like resource optimization, reduce energy consumption and waste, synergy creation, the achievement of a critical mass and increased benefit for all partners [4].

Knowledge management in networks

In order to achieve a path of creativity, quality and innovation, companies and specially designers are increasingly dependent on knowledge. This knowledge enables companies to move toward the goal of understanding customers and using that understanding to make it easier for the company to provide products and services desired by customers.

According to Fornasiero et al. [5] the knowledge sharing in network management is based on:

- Hybrid centralized-decentralized models for data and services to allow private confidential data (like Design data) to be kept by the owner and less private, commercial and collaboration data, to be stored in third party data-service centers, thanks to the new IoS technologies of ICT resources virtualization (i.e. Cloud Computing);
- Value added services to be provided by reliable service centers set up and maintained by IT professionals, while Utility Services (like interoperability and collaboration services) are offered by distributed service centers based on the existing infrastructure (like COIN proposes);
- Real time data capture from the field provided by Open Source platforms (like ASPIRE) and proper enhancements of it to allow the acquisition of eco-compatible data series.

From a knowledge perspective, the reference model to be developed shall explicitly address the knowledge exchange that is necessary between involved partners to ensure sustainability and efficient design, development, production and distribution.

Co-design and sustainability

Looking in details to the product phases, and in particular to product design it emerges that it is important to focus on involvement of customer both for product functional definition (through product configuration systems) and for product style definition (through co-design systems).

Today product co-design tools commercially available do not either encapsulate customer orientation as a common feature or foresee real interoperability for an effective distribution of the design phase along the chain.

Collaborative design tools empowers the consumers to design their own products by providing them the ability to collaborate in an informed design process not only regarding aesthetics, prices and delivery times, but also resources consumption and social responsibility, implementing sustainability parameters in the design phase and relying on the synchronization of the design along the supply chain.

For instance, in the footwear industry, actors collaborating to shoe product definition are today acting in a fragmented supply chain, counting more than 20 steps including materials and components subcontractors. In such a context, product engineering is spread between different actors and interoperability is still an open issue.

In order to support this need, a co-design collaborative sustainable framework will have to provide interoperability mechanisms to collect internal CAD data, exchange product design information with PDM systems of component suppliers along the chain and recollect intermediate part engineering in the central CAD, from the customers to stylists and designers.

Concerning sustainability viewpoint, first of all it has to be underlined that garments and shoes are complex products in terms of their environmental impacts. A sustainable framework will have to address the information retrieval related to each product and its production - at any level of depth along the supply chain - by any authorized user, along the whole product life cycle to enable products and related components traceability and sustainability assessment.

This ability will have to be assured by an implementation able to exploit the emergent and pervasive infrastructure of the Semantic Web, joined to an effective adoption of state of the art RFID and sensor technologies. Consumers and the whole distribution system will be able to verify the quality of products before their purchase and during their utilization. On the other side, designers will be allowed to model their product after a precise connotation of all the chosen product's components and producers will be able to verify such characteristics along each step of production and supply.

The application of the LCA methodology will also be enabled and take advantage of the ubiquitous availability of information on the Semantic Web and through an integration and derivation of data from bill of materials during product conception, design and production.

Designers suffer from a scarcity in tools and methodologies in order to evaluate easily the impact related to design choices in advance. Current tools are frequently costly and not suitable for the use within firms especially within SMEs [6]. The main barrier is the high level of customization and changeability of such products. For each firm, the whole portfolio may include several hundred of models each requiring specific materials and modifications. The introduction of new advanced materials in place of traditional materials introduces a further complexity in sustainability impact assessment.

CORENET APPROACH

Future research for healthy fashionable products needs to be based on the following pillars according to figure 1:

P1. Reference Framework for Collaborative Supply Networks -The reference framework model for collaborative supply networks addresses, orientates and integrates all aspects both at organizational and technological level concerning interaction of organizations, business processes, considering co-ordination and synchronisation of contents, as well as information exchange and software application modularity for improvements in data management, in order to create a seamless flow of information from market to design and development, to production and distribution that supports sustainability assessment.

P2. Innovative consumer-driven environments for product design - This pillar addresses the implementation of innovative environments for consumers and suppliers collaboration and knowledge management. The goal is to create a novel concept that enables the vision of an "empowered-to-design" consumer from one side, and the creation of market and design knowledge within a social network environment.

P3. Methods and tools for supply network configuration and distributed production planning - In this pillar, innovative and adaptive services for production process modeling and supply networks formation and management shall be based on a distributed interaction system to integrate different actors (components suppliers, outsourcers, service providers, retailers, customers) of different sectors collaborating in dynamic networks. Moreover product and process quality control based on environmental impact parameters shall be developed through a shared platform for eco-monitoring. Main contribution in this pillar shall be based on developing innovative services for supply network management based on existing technologies like SOA, EDA, Product Tracking & Tracing, web2.0, semantic web and existing commercial applications.

P4. Rapid manufacturing technologies for small series industrial production - Rapid manufacturing technologies shall enable the flexible, energy and eco-efficient production of specific added value components/parts of consumer personalized goods. In particular reduction of set-up time is crucial in the production of small series in order to avoid loss of time when changing models. Two particular phases of footwear production process (printing and engraving leather) shall be taken into consideration because they represent critical steps for the personalization of leather in the definition of the new customized models. Cutting-edge technologies for developing a multi-process machine based on laser decoration and engraving for production of small series specifically developed as a unique integrated unit coping with high speed laser cutting, laser engraving, laser marking.

The proposed CoReNet approach [6], intends to support textile, clothing and footwear companies in the implementation of new models for small series production for health and fashionable goods following the Competitive Sustainable Manufacturing (CSM) paradigm [7] and current initiatives of European Technological Platforms like Manufuture [8] and Footwear. The project intends to support the whole value chain to get and manage consumer data to investigate its needs; involve consumer into design and product configuration phases; exchange consumer data through adequate data models and secure systems; manage the collaboration with suppliers in order to plan and distribute on time; implement innovative manufacturing technologies; deliver timely the product to the final customer; and monitor the quality and sustainability of products.

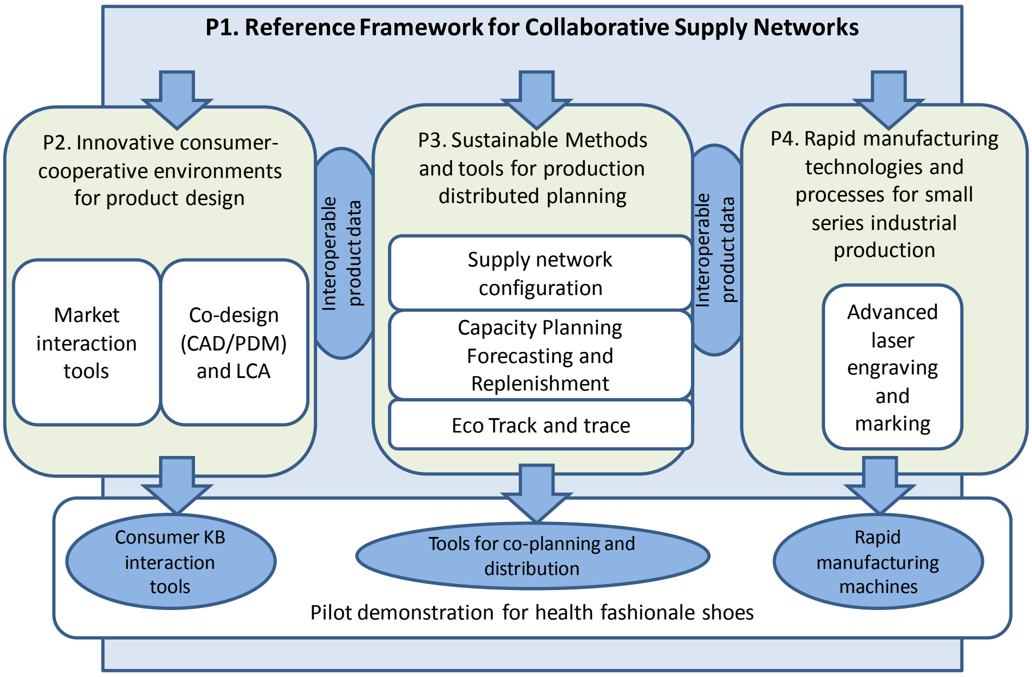

Fig. 1. CoReNet Research Pillars

Consumer Target Group Analysis

In the case of CoReNet project the target is mainly on specific market segments where it is necessary to find the right trade-off between healthy and fashionable features of products for disabled, diabetic, obese and elderly people.

Today, consumers demand for personalization and value adding of harmonized products of the Textile, Clothing and Footwear Industry (TCFI) is not only in terms of aesthetics, but also in terms of health, innovative functionalities and environmental impact.

The analysis of the target groups' requirements which is part of this work is based on existing literature and on field questionnaires made to European people belonging to these categories.

What turned out is that these target groups represent a share of the market which is getting larger and larger, asking for products to fulfill their requirements in terms of improved comfort and wearability, like to protect the body from regular environmental impact (e.g. heat, cold, water, humidity) in a high comfort and high quality. This means for TCFI companies to refocus design and production of their clothing and shoe models based not only on fashion requirements but also on other features which need to be taken into consideration from the design phase changing the approach to product conception.

Business Requirements Analysis

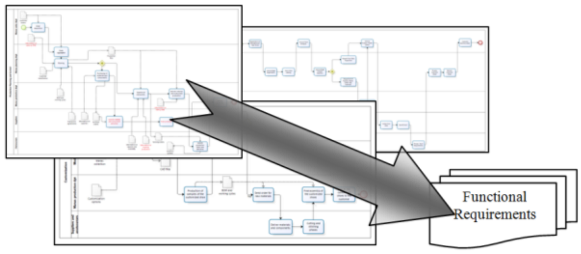

Fig. 2. Business Requirements gathering

In order to identify the functional requirements for CoReNet framework, a set of business requirements analysis was performed in key industrial players of TCFI supply chain. This comprehensive analysis allowed the identification of functional requirements (see fig. 2) and use case scenarios (overlapping both the footwear and clothing scenarios) relevant to the definition of the CoReNet proposed reference model.

The functional requirements of specific customers groups and relevant players in the TCFI supply chain established the background for the future developing of a supply chain solution. This approach enables a sustainable approach based on cost, social compliant and eco-efficient design and production of customised products that fully satisfy the customers considering their health as well as their desire for fashionable products.

Proposed Reference Model

The Reference Model resulting from the functional requirements specification is based on mapping TCFI processes at three levels: strategic, tactic and operative according to three perspectives (cf. Fig.3):

Organizational Perspective: offers the definition and the instantiation of innovative production paradigms based on new manufacturing concepts such as the agile manufacturing or even hybrid solutions that include lean practices and cost minimizing approaches. Comprises also process planning methods and configuration procedures of the supply networks through collaboration mechanisms. Also includes the formalization of interaction processes with customer requirements and needs in order to complete the design of the value chain.

ICT Perspective: defines the infrastructure that supports the services, methods and tools necessary for the network operation. This infrastructure maps the information and ICT services necessary for networking management during the different processes identified (from design, to product configuration, to production planning, to production to delivery).

Knowledge Perspective: The knowledge perspective of the reference model depicts both the available knowledge and business intelligence in the network and the required knowledge exhibit by the different stakeholders along the network. This perspective deals with all different kinds of knowledge from partner competences to knowledge about eco-material properties, traceability, availability and process capabilities.

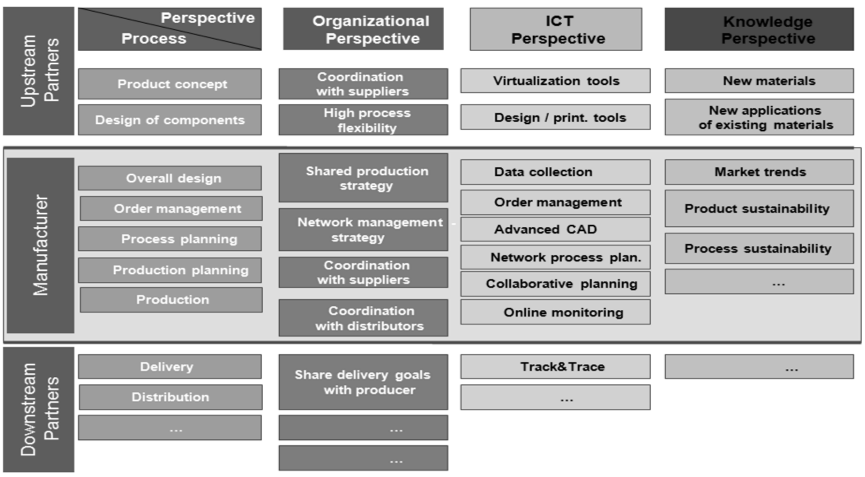

Fig. 3. CoReNet Proposed Reference Model

The proposed Reference Model will be applicable both to companies producing customized goods according to the traditional framework where most of the production is kept internally and to companies doing their business on online sales, externalizing most of the other processes. This requires different levels and means of collaboration in the three different perspectives (organizational, ICT and knowledge) which need to be investigated.

CONCLUSIONS

In the present context, the specific objective of this new research is to increase significantly the sustainability of value creation of small series health fashionable consumer goods and in particular of footwear and accessories, for emerging social niches like elderly, obese, diabetics and disable people.

The CoReNet collaborative project responds to such needs by conceiving a new holistic framework, meant as a set of methods, tools and technologies for sustainable small series industrial value creation of health fashionable goods.

The Core Net project follows the Competitive Sustainable Manufacturing (CSM) paradigm and current initiatives of three ETPs (Manufuture, Footwear, Textiles and Clothing) aimed to for strengthening the European manufacturing sectors for the benefit of the European industry and of the consumer.

The ongoing European project “Customer-oriented and eco-friendly networks for healthy fashionable goods (CoReNet)” aims to provide TCFI companies with the tools and methods to: support supply chain design and re-configuration based on standardized and distributed data management; provide network-wide track and trace for product and process sustainability monitoring, allowing the visibility of supply chain in terms of quality and sustainability; development, scale-up, and integration of innovative manufacturing technologies and processes for TCFI production which follow the rapid manufacturing paradigm.

Until now the project research work allowed the definition of a Reference Model that set up the foundations for the development of the envisaged future technologies and tools that support network operation. The following phases include the instantiation to specific companies’ requirements of the reference model according to their business model in order to support the definition of sustainable processes in the path to small series production of healthy products. The model will be evaluated and improved in the CoReNet project together with the industry partners and the customers through the development and prototyping of the main outcomes of the project.

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CAPACITY BUILDING FOR SOCIAL DEVELOPMENT: A COMPETENCY BASED MODEL FOR EDUCATION IN SOCIAL DEVELOPMENT

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Abstract: Social Development is implied in concepts such as Capacity Building (CB) and Institution Development (ID) which are terms increasingly used in technical cooperation projects in developing and transition economies. ID and CB projects can be designed and implemented at different levels of complexity such as national development (macro), sector specific development (meso) or organization level (micro). Examples of ID/CB projects could be e.g. reconstruction of a war-torn society (macro-national), development of an export oriented fishery sector (meso-institutional) or an effectiveness improvement project of an enterprise or of a public administration (micro-organizational level). Social Development does not yet exist as a separate academic discipline but is close in practice to organization development. In light of the growing demand for more CB/ID projects worldwide, it is of imperative urgency that new curricula be developed for undergraduate and graduate teaching programmes in social development. . This paper draws on the findings of eight years of deliberations by OD experts on what the core foundations of an OD programme should consist of and proposes a foundation core curriculum for undergraduate and graduate level teaching of programmes in Social Development.

Keywords: Social development, capacity building, institution development, organization development.

STRENGTHS AND WEAKNESSES OF CURRENT OD THEORY AND TEACHING

The current core foundations of OD are deeply rooted in North American Universities, where the founders of OD worked and lived. (Shephard, Bennis, Argyris, Schein, Blake, Mouton, French, Maslow, McGregor, Likert, Herzberg, Zand, etc.) . For instance, the authors of the now famous Addison Wesley “six pack” (1969) grew up in the academic world. (Bennis, Lawrence & Lorsch, Schein, Blake & Mouton, Walton, and Galbraith) All of the “foundation literature” listed in the 2003 edition of the Bibliography of Organization Development and Change (Varney et al.p. 9-15) was authored by academics. (Argyris, Beckard, Bennis, Bradford, Boss, Lippitt, Schein, Chin, Dyer, Galbraith, Herzberg, Katz, Kahn, Lewin, Likert, Lippitt, Nevis, Watson, Westley, McGregor, Maslow, Roethlisberger, Vaill, Tannenbaum, Weschler, Massarik, Westgaard, and Beckard etc.).

However, while it is true that the core foundation of current OD curricula have been strongly influenced by US academics especially during the period 1945-1995, the “grandfather” of OD, Kurt Lewin, was a German born and educated social psychologist who taught and guided the academic career of most people listed above. Kurt Lewin was a practicing social scientist who besides being a researcher and academic was also very much engaged in social development and in community development. Kurt Lewin and others at the New School of Social Research in New York City did not narrow their focus on intra-organizational dynamics. Their research focused on individuals, groups, organizations and the larger social settings including the embedded political and administrative environment. (Saner, 2004). It is also equally apparent to all currently active OD practitioners that OD theory and practice, as taught in most US graduate programmes, is too much focused on the private sector and US business contexts which are not directly transferable as is to the rest of the world nor are they sufficiently adequate for social development.

NEED FOR BROADENING SCOPE OF OD TO FIT SOCIAL DEVELOPMENT

The Scope of OD theory and practice needs to be expanded to better fit with the complexity of today’s’ world no matter whether an OD intervention is planned for the private, public or international organization sector. The following are three main arguments in favour of a broadening of OD theory:

a) Globalization is increasingly deepening the inter-relatedness of business resulting in a multitude of inter-dependencies along the value chain of production spanning the globe and involving a large number of suppliers located in different countries. Today’s enterprises are embedded in several environments consisting of local, regional, national and international markets. Not all enterprises are internationally linked but even domestic enterprises are affected by globalization since they interact with local subsidiaries of foreign multinational. Any OD change project involving the total enterprise would hence have to take into account the larger institutional setting and include interfaces outside the organizational boundaries.

b) In addition to the above, enterprises active in developing countries need to address the issue of how to manage the interface with non-business partners including e.g. tribal leaders, local NGOs, international NGOs, labour movements etc . Global companies must succeed in the business they are in and at the same time show competence in managing multiple stakeholders at home and abroad. While it is of key importance to have the right products and services at the right price, global companies might not be able to deal successfully with obstacles emanating from outside of their direct sphere of control. Recent examples of such cases are the destruction of production equipment and recurrent violence and kidnappings of Shell staff in Eastern Nigeria by dispossessed and oppressed minority tribes. (Saner, Sondergaard, Yiu, 2000).

c) Change and development interventions in the social sector require radical rethinking of basic tenants of OD theory. There is more to organization development and change than focusing on intra-organizational development. Rupert Chisholm (1998) contributed pioneering steps towards an enlarged scope of OD. OD experts should also be involved in larger scale development projects such as regional development or nation building in developing and transition economies. David L. Brown and Ken Murrell have extensive experience working on such larger scales in developing and least developed countries for NGOs, governments and public sector organizations. Other colleagues have similar experiences including non-American scholars such as Vijay Padaki (2003). We have to upscale our willingness to meet up scaled challenges. There is no reason why such important tasks should be left to economists or Pentagon officials. At the same time by broadening our scope of study and work, we need to expand our current sources of theoretical knowledge and draw on theories that offer adequate constructs for larger OD system studies such as chaos and complexity theory.

OUTLINE OF COMPETENCIES SUGGESTED FOR FUTURE TEACHING COURSES ON ORGANIZATION AND SOCIAL DEVELOPMENT (OSD)

What follows is an outline of competencies which future teaching courses on organization and social development (OSD) should attempt to cover. The outline below is based on the pioneering work which was done over several years under the leadership of Glenn Varney within the context of the ODC division of the Academy of Management. (Glenn Varney, 1999). The author as well as several others participated in this lengthy process of defining OD competencies for graduate level educational programmes. The reason for this extensive investment of time and energy was to the realization that the field of OD remains ill-defined, is vulnerable to misrepresentation by unethical vendors of consulting service and needs to become more globally validated.

Building on the group’s pioneering work; the author lists the key components of the ODC/AOM study and invites reactions by the practitioners of social development to start an adaptation process of the competencies listed below to the needs and requirements of educational courses on social development. Comments and suggestions for additions are welcomed by the author.

FOUNDATION KNOWLEDGE OD CORE COMPETENCE

(shortened version of Glenn Varney et al.’s report)

Skills

Our vision for those persons wishing to study and develop in the field is that they possess certain foundational competencies. These competencies should serve as the introduction building blocks upon which OD&C competencies are developed. We believe that successful learning and application of core OD&C knowledge and skills cannot be achieved without a basic level of foundational competency to start with. (e.g. research methods as applied to organizational diagnosis.)

Finally, it is our belief that Master level degrees in OD&C granted by any institution should in effect certify a specific level of competency both in foundational as well as OD&C knowledge and skills.

The foundation and core OD&C competencies are cited here with minor revisions as they were presented in the Winter 1999 edition of the OD&C Newsletter. You will also find in Appendix I the same list supported by references to literature for both the foundational and core competencies.

The competencies we have identified include the following:

I. Foundation Knowledge and Skills

A. Foundation Knowledge

1. organization behavior

   a)organization culture,b) work design ,c) ,relations (giving and receiving feedback), d) power and politics , e) leadership , f) goal setting, g) conflict , h) ethics ,

2. individual behavior (psychology)

   a) learning theory , b) motivation theory , c) perception theory

3. group dynamics

   a) roles ,b) communication processes ,c) decision making processes, d) stages of group development , e) leadership,

4. management and organization theory

   a) planning, organizing, leading, and controlling ,b) problem solving and decision making, c) systems theory, d) contingency theory , e) organization structure, f) characteristics of environment and technology ,g) models of organization and systems effectiveness ,

5. research methods/statistics

   a) measures of central tendency ,b) measures of dispersion ,c) basic sampling theory, d) basic experimental designs (case study, post-test only control group, etc.), e) sample inferential statistics,

6. comparative cultural perspectives

   a) dimensions of national culture, b) dimensions of industry culture (public, private, ...) , c) systems implications ,

7. Functional knowledge of Business and Management principles and practice.

B. Foundation Skills

1. interpersonal communication: listen, feedback, articulate , 2. collaboration/working together, 3. problem solving , 4. using new technology, 5. conceptualizing ,6. project management,7. present/ education/coach

II. Core Knowledge and Skills

A. Core Knowledge

The core knowledge of OD includes advanced theories, concepts, and frameworks that are directly related to the art and science of organization development and change. Mastery of each assumes the student possess the foundation skills and knowledge listed in above.

1. Organization Design: The decision processes associated with formulating and aligning the elements of an organizational system, including, but not limited to structural systems, human resource systems, information systems, reward systems, work design, political systems, and organization culture.
   a) The concept of fit and alignment.
   b) Diagnostic and design model for the various subsystems that comprise an organization at any level of analysis, including structure work, human resources, info systems, reward systems, and so on.
   c) Key thought leaders in organization design.
2. Organization Research: Field research methods, interviewing, content analysis, questionnaire and interview protocol design, designing change evaluation processes, longitudinal data collection and analysis, understanding and detection of alpha, beta, and gamma change along host with a of quantitative and qualitative methods.
3. System Dynamics: The description and understanding of how systems evolve and develop over time. The understanding of how systems respond to exogenous and endogenous disruption as well as planned interventions (e.g. evolution and revolution, punctuated equilibrium theory, chaos theory, catastrophe theory, incremental vs. quantum change, transformation theory, and so on.)
4. History of OD&C: An understanding of social, political, economic, and personal forces that lead to the emergence and development of OD&C, including the key thought leaders, the values underlying their writings and actions, the key events and writings, and related documentation.

   a) human relations movement, b) NTL/T groups/sensitivity training, c) survey research, d) quality of worklife, e) Tavistock Institute, f) key thought leaders , g) humanistic values, h) statement of ethics

5. Theories and Models for Change: Basic action research model, participatory action research, the planning model, change typologies (fast, slow, incremental, quantum, revolutionary etc.) Lewin¡¯s model, transition models, and so on.

B. Core Skills

1. Managing the Consulting Process: The ability to enter, contract, diagnose, design appropriate interventions, implement those interventions, manage unprogrammed events, and evaluate a change process.
2. Analysis/Diagnosis: The ability to conduct an inquiry into a system¡¯s effectiveness the ability to see the root cause(s) of a system¡¯s current level of effectiveness. The core skill is interpreted to include all systems, individual, group, organization, and multi-organization, as well as the ability to understand and inquire into one¡¯s self.
3. Designing/Choosing Appropriate/Relevant Interventions: Understanding how to select, modify, or design interventions that will effectively move the organization from its current state to its desired future state.
4. Facilitation and Process Consultation: The ability to assist an individual or group toward a goal. The ability to conduct an inquiry into individual and group processes such that the client system maintains ownership of the issue, increases their capacity for reflection on the consequences of their behaviors and actions, and develops a sense of increased control and ability.
5. Developing Client Capability: The ability to conduct a change process in such a way that the client is more able to plan and implement a successful change process in the future, utilizing technologies of planned change in a values-based and ethical manner.
6. Evaluating Organization Change: The ability to design and implement a process to evaluate the impact and affects of change intervention, including control of alternative explanations and interpretation of performance outcome

CONCLUSION

While awaiting further developments of the above list of OD competencies in order to make the list fit with educational requirements of a social development curriculum, we would suggest to start with a re-naming of our field as Organization and Social Development (OSD). The new name would clarify the basic facts of OD reality today. Organizations function within multiple social systems that in turn impact organizations and social development. OSD in fact requires competencies in change and development theory and practice applicable to the macro, meso and micro level or social reality.

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PROMOTION OF SCHOOL SUCCESS THROUGH PBL – PROJECT BASED LEARNING – AND PROJECT MANAGEMENT GOOD PRACTICES BASED ON PROJECT MANAGEMENT BODY OF KNOWLEDGE (PMBOK®)

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Abstract: This paper presents a set of project management good practices used in the context of PBL – Project Based Learning - by teachers from the Organization and Management Department of ISEP in Work Management modules and courses, to develop students' basic project management skills. This set of good practices is based on PMBOK® - Project Management Body of Knowledge – (a PMI's - Project Management Institute – project management standard) and aims to contribute to the improvement of academic success in ISEP. We believe that the use of inadequate work methods is an important cause of student's failure.

Keywords: Education, PBL - Project Based Learning, Project Management, PMBOK.

INTRODUCTION

After several years of professional management, consulting and teaching, it became clear to us the difficulty that students and other professionals have to effectively and efficiently structure the various activities undertaken by them.

Some situations are paradigmatic. In a course of the second year of the Computer Science Degree, students developed small computer programs that often did not work properly due to basic inconsistency errors of its components. We then started to require students to also present a flowchart we thought would help them to program their tasks and allow us to analyze the program's structure and find errors. Surprisingly, we found that students developed the program first and then elaborate its flowchart. When we began to require that, before starting to program, they should carry out a flowchart, we heard expressions that amazed us even more: "after elaborating the flowchart, programming is much easier" or "because of the flowchart we made fewer errors."

In a management post-graduate training courses we also felt that many students continued to demonstrate their inability to respond timely and in a structured way to tasks and projects they were asked to do, even after attending management courses that involved several hundred hours of work.

Through experience, we found out that Portuguese students tend to have success problems, even at a higher education level, because Portuguese people tend to have work method problems. As Hofstede states [1], national culture, is a collective programming, software *of the mind* that shapes the way people feel, think and tend to act. This programming has an impact in several dimensions of our life: management, art, social organization, etc. No group of people is immune to the influence of national culture.

It became clear to us that ISEP students needed help in order to develop more productive working routines.

Therefore, when course reviews were undertaken in ISEP under Bologna process, the Organization and Management Department suggested the introduction of courses or modules in the first undergraduate year so as to develop methodological skills, necessary for the attendance of higher education. We wanted to develop skills like reporting, time management, effective study, or the ability to manage academic projects. Thereby, we intended to contribute to the improvement of school success, and also to the professional performance of ISEP students, since, if they acquire good work practices throughout their engineering degree, they will apply them when working as engineers.

To achieve these objectives, we knew we would have to move from the conceptual plan to a plan in which students would have the opportunity to apply new knowledge to everyday situations. Because of that, we decided to use the Project-based learning (PBL) methodology.

PBL is an educational strategy to improve student's learning that is based on the elaboration of projects, usually in a student working group. Students learn and develop skills because they want to be able to do the tasks needed to successfully complete the project. In fact, PBL is a model for classroom activities that shifts away from the classroom practices of teacher-centered lessons and instead emphasizes learning activities that are interdisciplinary, student-centered, and integrated with real word issues and practices. [2]

However, practice has shown us that this methodology has not solved all our problems and has not allowed us to reach all our objectives. As we have already said, Portuguese students typically have success problems and one the causes of these problems is the lack of structured working methods, and the tendency to work in an instinctive manner, without a previously prepared plan. Thus, we understood that it would be essential to combine PBL with a project management methodology, allowing students to develop project management skills that would enable them to organize and structure their academic work.

With the aim of helping students to develop project management skills, we developed a set of good practices for managing task and projects, based on PMBOK® - *Project Management Body of Knowledge* [3].

"The PMBOK Guide is the standard for managing most projects most of the time across many types of industries. This standard describes the project management processes, tools, and techniques used to manage a project toward a successful outcome."[1] And therefore, applicable also to academic projects' management.

We tried to identify a set of PMBOK®'s basic project management good practices, that would be implemented to the context of academic tasks and projects.

We intended to develop a document (that we present below), simple and very brief, which we call "Project management good practices".

This methodology is being applied to the context of PBL - Project-Based Learning activities. Briefly, when we propose a project, students are required to demonstrate that they are using these project management good practices. In this context, a project is a way for students to develop more effectively a set of skills.

[1] Project Management Institute A Guide to the Project Management Body of Knowledge: PMBOK Guide; 4th ed. 2008, Project Management Institute, Inc., Newtown Square, PA. page 13

PROJECT MANAGEMENT GOOD PRATICES

Academic projects and tasks are simply referred as projects. Because these guidelines are generic, they should be applied to all kinds of projects.

This set of good practices is based on PMBOK® five process groups: initiation, planning, implementation, monitoring and closing.

Project Initiation

Students, regardless of their level of education, often obtain unsatisfactory grades or are forced to redo projects, partially or totally, just because they don't know or don't understand all the requests they must fulfill.

This type of errors occur both in school projects and professional projects, and have several causes: the tendency to start work before clearly establishing what should be done, incomplete requests, vague or inconsistent goals, communication problems, wrong or incomplete information obtained second hand or third hand from colleagues, to quote just a few.

So the first thing for students to do, after receiving a request for the elaboration of a project, is a detailed and rigorous analysis of its objectives, specifications, terms, and implementation rules.

Then, it is very important to confirm the interpretation of the request or statement, and to clarify the different aspects raising doubts or uncertainties. This can be done by writing a summary of the scope ("what" is included in the work) and all its specifications, and by validating this summary with the person or persons responsible for the project.

Without this clarification, project teams shouldn't proceed to the implementation stage; otherwise, it is very likely that it will be necessary to repeat some or all the work done.

Project planning

Once project scope and specifications are clearly set, it is possible to move on to the planning stage. Let us recall some important advantages of planning:

- A better understanding of the work to be done.
- A preliminary assessment of various alternatives in order to implement the different project components.
- Anticipation of problems and their solutions.

- More effective team work, as the result of a better group coordination and harmony.

All this learning and preparation is often more important than the plan itself.

The planning is based on estimates regarding the work and the time needed to accomplish each task or group of tasks, considering the various constraints, for example, the number of hours per week a student can (and wants to) work. Students' or group's experience and peer and teachers' feedback are very important to the quality of the estimates.

A plan shouldn't be regarded as one of the ways the project can be carried out. A plan must be fulfilled, or it is completely useless. In order to fulfill the plan, it must be based on what we can and will perform, not on what we would like to accomplish. But a plan is a mean, not an end in itself, and, therefore, can and should be changed whenever necessary.

A plan must establish clear, prioritized, quantified (if possible) and time defined goals, and should be shared and accepted by all involved (students and teachers).

It is important that individual students or groups choose the goals they want to achieve: the grade, work components they want to perform, etc.. Obviously, these objectives have to be compatible with project rules and requests, and in case of doubt, must be validated by the teacher in charge.

It should be noticed, that, in addition to project team and teachers, there are often other elements involved in, or affected by, the implementation, orientation or assessment of a project (usually called stakeholders). For example, other courses' teachers, external entities such as internships, or other students that receives or provides input from or to the project.

Often, these stakeholders may affect the development and final validation of the project. Therefore, for a project to be successful, it is essential to balance the objectives of all stakeholders, in particular those that have the effective capacity of assessing or influencing it. In order to accomplish this, before initiating the execution stage, it is necessary to identify and negotiate objectives and constraints with each (important) stakeholder.

In projects carried out by a project team, of medium or large size, it is worth appointing a project manager, whose (important) role is to ensure the project team coordination and representation, to monitor plan implementation and carry out its revisions, to ensure good communication with all stakeholders, to check and promote the performance of team members to prepare and coordinate meetings, to name a few. This coordination enhances the group's work, but it implies an overload to the project manager, which must be taken into consideration when distributing tasks among team members.

For most people it is very difficult to focus their attention on several issues simultaneously. In general, it is a good strategy to focus on a reduced number of projects at a time.

A simple and effective way to plan

- **Start by establishing "what" to carry out**: identify and list all project outputs, which we call "deliverables" (everything that should be handed to "clients" - the teacher or other stakeholders -, like the draft of the work, planning or progress reports, project components, the final report and other requirements). Identify and list the specifications of each deliverable (deadlines, technical requirements, form, etc.). If deliverables are very big, we can divide them into two or more components and these into sub components. For example, if the delivery is a prototype of a rocket, it can be subdivided into three deliverables: the propulsion system, housing and rocket guidance system. In turn, the propulsion system could also be divided into several deliverables: ignition system, engine, storage system and fuel supply. And so on.

- Then **define "how" to perform each deliverable**: think of what is the best way to carry out each deliverable and list the sets of tasks (also called work packages) needed to produce each deliverable.

- Once knowing the tasks that must be carried out, it is then possible **to estimate the means, the work and time required for each task or group of tasks (called work package)**, and with these data, to schedule all project tasks. Tasks or work packages should also be allocated to project team members. In the scheduling process, time limits and interdependencies/ precedences between tasks should be taken into consideration. It is recommended to set dates for the beginning and the conclusion of each deliverable. This makes it possible to split the project into phases and create several moments of control. The Gantt chart is an excellent tool to schedule (and monitor) projects. The scheduling of a project it is often a dynamic process: it can require several iterations before we succeed in including all tasks and constraints in the required deadlines.

We must always remember that a plan is only worthwhile if it covers all work needed, but if it is also as simple and easy to use and to update as possible. The accurate level of detail of a plan depends on the size and complexity of each project.

The implementation and monitoring stages

It is important to periodically compare the plan and the actual status of the project, to detect, as early as possible, deviations in scope, schedule, work load or others. An easy way to make this assessment is to check the stage development and fulfillment of the specifications of each deliverable. The plan must be reviewed and updated, if necessary, to continue to be useful. To perform without a plan, or abandon the plan during execution, is like sailing without destination and a route: the risk of failure is much greater.

Permanent care should be put on filling out all the requirements. It is usually better to develop first the deliveries or project specifications that are mandatory, and only later, if possible, to develop non-binding deliverables. A common mistake is to enhance secondary goals and neglect what is essential (like de layout instead of the content of a report).

One thing to carefully consider is the management of changes. It is rare for a project being carried out without undertaking some change to the original plan. So, with what criteria should changes be made? First, it is necessary to evaluate the impact of any change in the agreed scope, execution time, extra work required and compliance with specifications. Then, it is essential for these changes to be validated by the relevant stakeholders, especially by the teacher in charge.

COMMUNICATION MANAGEMENT - RECORD AND REPORT AGREEMENTS AND OTHER RELEVANT INFORMATION

There can be no good coordination without good communication.

So, communication is a critical factor for the success or failure of any project, especially in team work, but also on individual projects. How often do we hear and use words like "I thought" or "I had realized that "or "I didn’t say anything because I didn’t know it was important”?

It should be defined from the beginning how the student or team members communicate with each other, with the teacher in charge and with other stakeholders. For example, they may create a list of e-mails for all relevant information to be forwarded.

Whenever there are meetings, decisions and changes, the appropriate information must be registered and communicated succinctly to all those who may need it. This can be accomplished through a brief memorandum sent and, if possible, signed by all the involved, including the teacher in charge.

It is particularly important to record and send to those involved, what has been established or agreed to, regarding the scope, term, the specifications or conditions of execution of a project, as well as its changes. This wards off many conflicts, lack of coordination and distress resulting from misunderstandings or loss of vital information.

Project closure

Although in a school environment, a projects’ closing stage is generally determined by delivery deadlines, we should not neglect a set of tasks and principles.

"Almost finished" projects imply an overhead and a scattering of work and project team “energy”, which can be very harmful. We can always improve a project, but we should confine ourselves to do the best possible, considering the requirements of other underway or planned projects. One should try to end a project as soon as possible and adequate.

Before the final presentation of the project, a general check should be performed to make sure that all deliverables are completed (and included) and all specifications are met. If possible, it is also recommended carrying out this check with the teacher, to ensure that the project is both completed and accepted. The project must be completed before the deadline, or there will be no time for any corrections.

After the project delivery and acceptance, the author or authors should assess how the whole project was planned, executed, managed and terminated. The purpose of this evaluation is to learn from the experience (what went well or what went not so well) and to improve the ability to estimate and plan, organize control and execute future projects – the so called, “lessons learned”.

All the materials used in the project should then be returned or assigned to other projects. Only then can we consider the project finished.

FINAL CONSIDERATIONS

This methodology has been successfully applied in the courses and working methods modules taught by the Organization and Management Department in various ISEP engineering degrees, particularly in the context of the implementation of Project-Based Learning to develop skills in project management, communication and teamwork, among others. We hope to be able to present concrete data soon about the success of this project. In the meantime we can argue that:

- When using these “project management good practices”, students are able to develop projects more successfully.
- In the context of PBL activities, students accept and learn more effectively these project management good practices.
- Other course teachers feedback is very clear: they feel that students are more able to carry out those courses projects, after learning this set of good practices.

We now intend to “sell” this set of good practices to ISEP’s engineering degree boards. We believe that if all courses demanded students to follow good practices, the academic and professional success of ISEP’s students would significantly increase.

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EFFECTIVENESS OF QUALITY MANAGEMENT FACTORS AND DIFFERENCE IN TOTAL FACTOR PRODUCTIVITY

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Abstract: It often happens that the quality management (QM) program is not a measure of high organizational effectiveness and satisfactory business performances, so it is of interest to explore the relation between QM critical factors and total factor productivity (TFP). The data were collected in the period 2004-2009 from a stratified random sample drawn from Serbian industrial firms certified according to ISO 9000 with a total number of 176 observations. The key result of this study is the confirmation of the hypothesis that there are statistically significant differences between TFP of industrial firms with high QM effectiveness and average productivity of all firms comprised by the sample. Positive and statistically significant differences in TFP were recorded on the basis of the above average scores for effectiveness of the three QM factors - leadership and management support for quality program, systemic approach and documentary evidence for quality system and product design according to user demands. Industrial firms with high QM factor effectiveness, such as training and involvement of employees have registered significantly lower multifactor productivity than average.

Keywords: quality management, performance indicators, statistical methods

INTRODUCTION

This study contributes, via field study, to an understanding of the very important practical question: "Does the effectiveness of quality management explain the difference in total factor productivity of industrial companies?"

The gurus of quality Deming, Gravin and Juran pointed out that quality means improved productivity and that they have similar roots [1]. According to [2] and [3] effective TQM practices improve delivery performance and productivity. But, practice shows that in a large number of companies TQM programs and standardization in the field of quality have not led to better performances. Works by [2], [4] and [5] indicate that the TQM program failure rate is higher than 30%. Today we encounter the results in favour of TQM but also those not justifying the invested resources [6,7]. Despite the existence of a considerable amount of research dealing with the QM and business performance, studies that analyse the relationtion between QM and factor productivity are rare and mostly limited to QM synthetic factor; namely, whether or not the company has the ISO 9000 certificate. For example, survey [8] uses a qualitative (dummy) variable which defines the ISO certification to determine the difference in TFP between the firms certified and not certified against their average TFP. Therefore the goal of this work is to conduct empirical research into the following:

1. Do QM factors influence the differences in TPF of industrial firms?
2. If the answer is positive, what are these differences and what is their direction?

The answers to these questions will help managers to allocate their limited resources to those QM categories which have a significantly positive influence on TFP, and assist the scientific public to gain a better understanding of the role of each element of QM in total factor productivity.

LITERATURE REVIEW

Although a literature review can identify over 1,000 articles on TQM, only a small part of these articles aim to test the strength of the relationship between TQM and performances [6]. The most frequently studied types of performance in the available literature are: quality performance, operating performance, market and financial performance, employee performance, customer satisfaction, innovation performance, project performance and aggregate firm performance and results of studies are very mixed [9]. Most frequently these are cross-section studies. In [7] the impact of TQM practice on the operating performance of firms over a 10-year period is confirmed. A few years later the same authors prove that TQM firms achieve better financial performance[10]. In [11] authors concluded that leadership, human resources management and customer focus proved to be strongly significant and positively related to performance. Study [12] show that ISO 9000 certification has a positive and significant effect on operational performance (productivity being one of its segments, Likert scale), but a positive weak effect on business performance. Authors in [13] deduce that QM has had a impact on the productivity, with benchmarking and training significant impact.

Available literature points out the need for research into the link between the critical QM factors and TFP, not cross-sectionally as usually, but longitudinally on a sample of adequate size. Productivity measuring by Likert scale should be overcome because it is possible to calculate it using the data from financial reports.

RESEARCH PROBLEM BACKGROUND

Consideration of the effectiveness of quality management in explaining the difference in the total factor productivity of industrial companies demands the defining of QM and TFP measures in order to test hypotheses:

H1. *Are there differences in TPF of industrial firms according to the QM factor effectiveness criterion?*

H2. *Firms having above average score for a certain QM factor register statistically significant positive and negative differences in TPF against average productivity of all firms in the sample.*

The research instrument developed in this study consists of two basic parts (quality management elements part and TFP calculation part).

QM elements, i.e. critical factors were investigated in this study using the research instrument from the work by [14]. The instrument was adapted to Serbian context (Table 1). Recommendations by [15] for characteristic of this type of investigations are fulfilled.

CRITICAL QM FACTORS	DIMENSIONS FOR CRITICAL QM FACTORS
Leadership and management support for quality program (LID)	LID1: Management assumes responsibility for quality LID2: Care of Department manager for quality LID3: Efforts of company management to improve quality LID4: Goal setting and quality policy LID5: Establishing regulation for quality LID6: Management encourages employees to independently make decisions and introduce innovations LID7: Motivating and rewarding the employees for high-level of job done
Training and involvement of employees (OB)	OB1: Responsibility of employees in Department of quality and other departments for quality OB2: Employees training as priority of the company OB3: Existence of financial resources for employees training OB4: Employees training to apply methods and techniques (tools) for quality improvement
Systemic approach and documentary evidence for quality system (SIST)	SIST1: Availability of data on quality to each employee SIST2: Analysis of collected data on quality in order to improve it SIST3: Existence of Department of quality SIST4: Possession of documents for quality system
Process approach (PROC)	PROC1: Differentiation and description of each process in the company PROC2: Continuous monitoring and improvement of key processes PROC3: Determination of quality measure for each process PROC4: Participation of machine operator in maintenance
Beneficial interaction with suppliers (ISP)	ISP1: Relying upon a small number of reliable suppliers ISP2: Selection of certified suppliers ISP3: Participation of supplier in program development ISP4: Participation in employees training in quality field at supplier's firm
Permanent quality improvement (PK)	PK1: Permanent tendency to eliminate internal process leading to waste of time or money PK2: Innovating production program PK3: Application of advanced IT to better analyze data and determining priorities to improve quality PK4: Revision of documents for quality system if necessary PK5: Application of methods and techniques to improve quality
Product design according to user demands (PP)	PP1: Coordination of employees from different organizational units in product development process PP2: New product quality as priority in its design and manufacture PP3: Analysis of possibility for manufacture and cooperation in product development

Table 1 -The dimensions of critical QM factors [14]

METHODOLOGY

The stated hypotheses were tested using data from different sources: a) data from the research instrument were used to gather data regarding QM, and b) from official financial reports used to collect data relating to TFP. Various statistical techniques such as validity and reliability testing, factor analysis and multiple regression were used.

Our sample was a genuinely random sample of Serbian industrial companies. The data was collected in the period 2004-2009 so that the analysis could be done longitudinally.

The data and sample

According to [16] the number of ISO 9000 certified organizations in Serbia in 2004 was around 400, and in 2008 it was 1987, which is still far from the desirable 2.5 certificates per one thousand citizens. Serbia is in an early stage of growth in the diffusion process of certifications [17] and as a country in transition has high rate of increase in the number of certificates [16]. Industrial companies in Serbia were the first to set off on the path towards TQM, which was expected since the standard was firstly developed for such companies [18]. Therefore, Serbian industrial companies are highly appropriate for an analysis of the link between QM and TFP. The sample is a stratified random sample drawn from the population of Serbian industrial firms certified according to ISO 9000 and includes companies of all 3 sizes from all 19 industrial sectors. Each industrial sector cell contained a minimum of 10 firms, so the questionnaire was sent to 190 industrial firms. Since the data was collected over a 6 year period, the sample was gradually reduced over time and the final one contains the non-balanced panel data for 50 industrial companies for the period 2004 – 2009. The total number of observations (time periods) was 176.

Analysis procedure

Empirical determination of differences in TFP presupposes the setting of criteria to define the binary/dummy variables relating to QM. In this study quality binary variables were determined on average score basis by factor analysis of the chosen variables. The chosen quality variable takes the value 1 for some firm in a certain year if the corresponding individual score is higher than the average score for that variable. The average score for a certain quality variable $(\overline{QV}_i)$ was calculated as an aggregate average of individual scores (QV_{ijt}) for all firms (j) for all time periods (t), i.e. $(\overline{QV}_i = \frac{\sum_{j=1}^{N} QV_{ijt}}{N})$. The variable Leadership for a certain firm is ascribed the value 1 if individual Leadership score for that firm is higher than average Leadership score for all firms in all time periods in the sample. As in our sample the average score for the Leadership variable $(\overline{LID})$ is 4.24 that variable is ascribed the value 1 in all observations where the individual score is higher than that average. ($LID_{jt} = 1$ if $LID_{jt} > \overline{LID}$, otherwise $LID_{jt} = 0$). The thus defining of QM variables makes possible to quantify positive and negative differences in firms' productivity with good (above average) Leadership against average TFP of all firms in the sample. Identical procedure of determining binary values (1 or 0) was applied to the rest of QM variables. Binary QM variables are not mutually exclusive. Approach through total factor productivity is the most common method of empirical evaluation of performance at the level of the company [8]. Although the approach basically uses the production function of various specifications, the linear logarithmic function is most frequently used:

$$\ln(y_{jt}) = \beta_0 + \beta_k \ln(k_{jt}) + \beta_l \ln(l_{jk}) + \delta_{jt} + \mu_{jt} \quad (1)$$

where $\ln(y_{jt}), \ln(k_{jt}), \ln(l_{jt})$ are the values or quantities of production, capital, and labour of firm (j) in year (t) (δ_{jt}) represents the level of total factor productivity (TFP) of the company (j) over time (t). In order to assess stability of the results, parameters of alternatively specified linear production functions are determined by using the regression technique. For the determination of the Cobb-Douglas parameters and Translog production function, ordinary least squares method (OLS) is used. Binary variables of the industrial sectors are used as control variables. The total factor productivity is calculated as a residual of the linear production function defined in the equation (1):

$$\ln TFP_{jt} = \ln(y_{jt}) - \beta_k \ln(k_{jt}) - \beta_l \ln(l_{jk}) \quad (2)$$

In our study, the output level is defined as a level of value added, labour as a number of employees and capital as a fixed assets value. Starting out from thus defined variables, the equation (2) is transformed into the following analytical form.

$$\ln TFP_{jt} = \ln(VA_{jt}) - \beta_k \ln(k_{jt}) - \beta_l \ln(l_{jk}) \quad (3)$$

Thus calculated value of the total factor productivity is used as a dependent variable when determining the differences in the productivity based on the value of the assessment of different quality variables.

$$\ln TFP_{jt} = \Phi_{jt}(\upsilon_{jt}) + \varphi_{jt} \quad (4)$$

where Φ_{jt} is the vector of the specific quality variables of the company (j) over time (t), υ_{jt} describes how such variables influence total factor productivity, whereas φ_{jt} represents a random error. In order to avoid restrictive assumptions on the elasticity of the production factors substitution assumed by the Cobb-Douglas production function, translogarithmic approximation is used for the determination of the production function parameters in the second specification:

$$\ln(VA_{jt}) = \beta_0 + \beta_k \ln(K) + \beta_l \ln(L) + \beta_{k^2}\frac{1}{2}(\ln K)^2 + \beta_{l^2}\frac{1}{2}(\ln L)^2 + \beta_{kl}\ln K \ln L + \delta_{jt} + \mu_{jt} ....(5)$$

For the determination of the level of total factor productivity in the conditions of simultaneity, in our study LP method is used, whereby the material cost is employed as a proxy variable. Total factor productivity as the measure of company performance was calculated in the same way as in equation (3) and the (β_k) and (β_l) parameters were determined by means of the LP method.

$$\ln TFP_{jt} = \alpha + \beta_1 LID_{jt} + \beta_2 OB_{jt} + \beta_3 SIST_{jt} + \beta_4 PROC_{jt} + \beta_5 ISP_{jt} + \beta_6 PK_{jt} + \beta_7 PP_{jt} + \sum_m \tau INDUSTRY_m \quad (6)$$

where $\ln TFP_{jt}$ is the level of multi-factor productivity in log terms, LID_{jt} ($LID_{jt}=1$ if $LID_{jt} > \overline{LID}$;otherwise=0), OB_{jt} ($OB_{jt}=1$ if $OB_{jt} > \overline{OB}$;otherwise=0), $SIST_{jt}$ ($SIST_{jt}=1$ if $SIST_{jt} > \overline{SIST}$; otherwise=0), $PROC_{jt}$ ($PROC_{jt}=1$ if $PROC_{jt} > \overline{PROC}$;otherwise=0), ISP_{jt} ($ISP_{jt}=1$ if $ISP_{jt} > \overline{ISP}$;otherwise=0), PK_{jt} ($PK_{jt}=1$ if $PK_{jt} > \overline{PK}$;otherwise=0) and PP_{jt} ($PP_{jt}=1$, if $PP_{jt} > \overline{PP}$;otherwise=0), whereby the regression coefficient (β) quantifies the differences in TFP of firms with good (above average) QM factors from average productivity of all firms in the sample. INDUSTRY is the vector of industrial dummy variables classified by the standard two-digit classification of activity. The QM data was screened for outliers and checked for normality and after that were exposed to factorial analysis to ensure that they constituted reliable indicators of QM factors. A cutoff loading of 0.450 was used to screen out those variables which represented weak indicators of the constructs [19]. Five variables failed to make this cutoff, leaving a total of 26 variables constituting 7 QM constructs (Table 2). This was followed by the calculation of the composite reliabilities, also shown in Table 2, where we see that 6 out of 7 constructs has a Cronbach alpha higher than 0.60 as recommended in [19]. Construct Product design according to user demands has a reliability of 0.550; however, further culling of variables will not improve this situation. Similar results were achieved in the study [20]. The factor scores were then calculated from the remaining variables to provide estimates for all 7 constructs, which were later used as independent variables in multiple regression.

Variables	Initial factor	Revised factor	Reliability of revised construct
LID1	.394	/	
LID2	.769	.788	
LID3	.752	.795	
LID4	.788	.862	
LID5	.586	.652	ά =.899
LID6	.150	/	
LID7	.318	/	
OB1	.214	/	
OB2	.804	.829	
OB3	.777	.796	ά =.814
OB4	.529	.564	
SIST1	.518	.518	
SIST2	.978	.978	
SIST3	.803	.803	ά =.718
SIST4	.796	.796	
PROC1	.772	.772	
PROC2	.875	.875	ά =.685
PROC3	.832	.832	
PROC4	.998	.998	
ISP1	.658	.658	
ISP2	.721	.721	ά =.633
ISP3	.751	.751	
ISP4	.637	.637	
PK1	.848	.987	
PK2	.315	/	
PK3	.758	.761	ά =.615
PK4	.795	.819	
PK5	.558	.591	
PP1	.541	.541	
PP2	.504	.504	ά =.550
PP3	.569	.569	

Table 2. Factor and reliability analysis for QM

Empirical results and discussion

The values of total factor productivity were established (lnTFP) on the basis of model (3) for three different production function specifications. Those values were then regressed in relation to the quality management variables, presented in Table 2. Based on model (6), Table 3. presents the regression dependence of TPF and those dummy variables which describe quality management.

Table 3 - Regression results-Dependent variable (ln TFP)

Quality variables	β	*Std. Error*	*t-statistic*	*p-value*
Cobb-Douglas (OLS)				
LID	0,88030	0,227097	3,8763	0,0002
OB	-0,85897	0,166642	-5,1546	<0,0001
SIST	0,185085	0,191226	0,9679	0,3349
PROC	-0,01546	0,151693	-0,1019	0,9189
ISP	0,212997	0,36943	0,5766	0,5652
PK	0,0250663	0,172339	0,1454	0,8845
PP	0,442793	0,147338	3,0053	0,0032
Adjusted R^2 = 0,542484				
Levinsohn-Petrin				
Quality variables	β	*Std. Error*	*t-statistic*	*p-value*
LID	0,866731	0,328538	2,6381	0,0094
OB	-0,819257	0,182686	-4,4845	0,0000
SIST	0,394971	0,231378	1,7070	0,0903
PROC	-0,202263	0,166753	-1,2129	0,2274
ISP	0,158844	0,387438	0,4100	0,6825
PK	-0,171589	0,185818	-0,9234	0,3575
PP	0,63854	0,174662	3,6559	0,0003
Adjusted R^2 = 0,651058				
TransLog (OLS)				
Quality variables	β	*Std. Error*	*t-statistic*	*p-value*
LID	0,758523	0,216324	3,5064	0,0006
OB	-0,882969	0,164361	-5,3721	<0,001
SIST	0,251765	0,187745	1,3410	0,1823
PROC	0,0528091	0,144295	0,3660	0,7150
ISP	0,200807	0,367608	0,5463	0,5858
PK	0,106123	0,168958	0,6281	0,5310
PP	0,455253	0,146471	3,1082	0,0023
Adjusted R^2 = 0,541602				

The results presented in Tables 2 and 3 confirm the H1 hypothesis and indicate that by following the criteria of high effectiveness for seven QM factors described with 26 dimensions there exist statistically significant differences in TFP of the firms with effective QM factor and average productivity of all firms in the sample. Content validity is secured by the selection of initial measurement items on the basis of voluminous international literature. The construct validity of each QM category was evaluated by using principal component factor analysis, whose results are presented in Table 2. All factors loaded well. The criterion validity of the model is determined by examining the Multiple R coefficient computed for the seven categories of QM and three measures of production function for total factor productivity. The results for the adjusted R^2 of 0.542484, 0.651058 and 0.541602 for three functions respectably present a high level of criterion related validity. Reliability was researched by means of the Cronbach alpha reliability coefficient; therefore the values in Table 2. meet or exceed prevailing standards of reliability for survey instruments. Considering the above findings, hypothesis 1 is proved. The results of the regression analysis of the seven QM elements on TFP (in Table 3) provide some insights and challenges from both practical and research perspective. Regression coefficients of the binary variable of leadership and management support for quality programs are positive and statistically strongly significant in all three specifications of production function. In the observed period industrial firms with above average score for leadership function, depending on the type of production function, registered from 113% to 141% (calculated as: $100 \cdot (e^{\beta} - 1)$) higher TFP than average productivity of all firms in the sample. High positive and statistically significant difference in TFP was also registered after the criterion of effective product design according to user demands. Firms with above average score for the product design factor according to user demand registered, in the observed period, higher TFP level by 67% compared to average factor productivity of all firms in the sample. Lower statistically significant but positive differences in factor productivity were also registered according to the criterion of the high effectiveness of the factors such as systemic approach and documentary evidence for quality system and supplier quality management. Firms with effective (above average) systemic approach and documentary evidence for quality system and supplier quality management had higher multifactor productivity by 32% and 21% ,respectively, compared to average productivity of all firms in the sample. The calculated differences vary depending on the type of production function which was used to determine the TFP level. Statistically non-significant and smaller scale differences (positive or negative) in factor productivity were registered after the criteria of high effectiveness factor for process management and continuous quality improvement. Firms with high effective process management had by 18% and 1.5% , respectively, lower factor productivity than average productivity determined on CD and LP production function basis. During the same period, the same firms had by 5% higher TFP compared to average productivity determined on the translog function basis. Firms with effective continuous quality improvement practice registered by 11% and 2.5%, respectively, higher TFP compared to average productivity determined on the basis of translog and CD specification of production function. In the same period, the same firms had by 16% lower TFP than was average productivity determined based on LP specification of production function parameters. Similar to the process management factor, the differences in TFP between firms with high effective practice of continuous quality improvement and average productivity are statistically non-significant, relatively small in volume and in direction, different, depending on the type of production function. In the observed period the firms with effective training and involvement of employees practice had by 56% to 59% lower TFP than average productivity in the sample. This negative difference in all three specifications of production function is highly statistically significant.

CONCLUSION

The key result of this study is the proof that there are statistically significant differences in TFP of industrial firms with highly effective QM and average productivity of all firms comprised by the sample. Positive and statistically significant differences in TFP were registered on the basis of above average score for effectiveness of the three QM factors - leadership and management support for quality program, systemic approach and documentary evidence for quality system and product design according to user demands. Industrial firms with highly effective QM factor of training and involvement of employees registered in the observed period statistically significantly lower multifactor productivity compared to average productivity of all firms in the sample. The study has also confirmed statistically non-significant differences relatively small in both volume and ambiguous in direction in TFP of the firms with highly effective QM factors of process management, supplier quality management and continuous quality improvement and average productivity of all observed firms.

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INTEGRATED MAINTENANCE MANAGEMENT OF SHOPPING CENTERS: A CASE STUDY

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Abstract: This paper presents the results of implementing a building key performance indicator (KPI), based on a unified scale, in a shopping center, in Portugal. We use a methodology that allows the detection of components and building systems that are in poor condition. The results show that the general condition of the facilities is good (BPI = 89). In general, the state of the components (P_n) is satisfactory and, in particular, the handling and lifting systems have the lower value of P_n=0,78.

Keywords: key performance indicators, maintenance management, facilities management, shopping centres

INTRODUCTION

In the current economic climate, the maintenance of complex buildings, like shopping centers, is performed under a tight budget context, and is essentially based on system's conditions. A maintenance model based on system's conditions to be effective, requires that maintenance service performance and efficiency evaluation, covering the different building systems and components, is performed. This paper presents the results of implementing a building key performance indicator (KPI), based on a unified scale, in a shopping center, in Portugal. We use a methodology that allows controlling the condition of components and systems, based on systematic performance tables, and develop a parameter that ensures clear detection of the elements and building systems that are in poor conditions. To this end, we will use two scales: one for the individual components (P_n) and a second for the entire building - the Building Performance Indicator (BPI). The first scale (P_n) combines criteria regarding the physical state, performance, fitness for use and preventive maintenance of various components and building systems. The second scale, the BPI, is a 100-point scale. The survey results show that the general state of the facilities is good (BPI = 89). In general, the state of the components is satisfactory and, in particular, the handling and lifting systems have the lower value of P_n=0.78.

A Shopping Center (SC) is a "shop open to the public", installed in a building, that can be classified as small, medium or large. In Portugal, they are modern buildings of trade/services type, with broad areas, featuring a shopping mall, with areas partially divided. Generally, the SC are multi-floor buildings, which include parking, several shops, technical, management, and shopping arcade. A commercial shopping center is essentially composed of large stores (anchors), medium and small size (satellites), conventional restaurants and fast food, and movie theaters. Communication between floors is assured by escalators and elevators, for consumers, and corridors that allow technicians to carry out the replenishment of the stores and waste transport, without interfering with public areas of the center, for the shopkeepers and the rear of stores. These corridors also serve in emergency situations as escape routes.

To ensure the functioning of the centers, facilities such as: power systems (switchboards, switchgear and cables) HVAC Systems (circulator pumps, chillers, fans, air handling units, cooling towers, etc.); supply systems for drinking water and wastewater (circulator pumps, distribution networks and collectors, chemical treatments), fire detection and fire fighting (automatic fire detection and fire-fighting network reels, a network of sprinklers, fire detectors, fire panels, etc.), surveillance and communication systems (closed circuit television, telephones, etc.), lifting and handling systems (elevators, escalators and passenger conveyors), are implemented in the technical areas.

The operation and management of a shopping center is vital to its success and is an intensive process, which is usually conducted by a multifunctional team, to cover areas of management, marketing, landscaping, maintenance, security and so on.

One of the functions of management is to optimize the return on investment, focusing on strategies that minimize operating costs, including property management, management of operations and facilities.

Maintenance plays a significant role in the property management. Maintenance is a necessary part of the SC business. The maintenance management systems should ensure that the SC operates efficiently in order to preserve and improve the owner's investment. Maintenance in the SC business is more than just repair equipment, and/or systems. It needs to assure the future of the asset (the SC), through a maintenance program that includes activities necessary to maintain the physical infrastructure and the support services.

This kind of management is important to ensure the quality and effectiveness of maintenance of facilities that usually vary in their size and type of construction.

In SC there is a set of facilities available to the public and shopkeepers like parking, WC's, signage, HVAC, elevators, escalators, public telephones and ATMs which provide comfort and convenience that attract consumers and retailers to visit it. Therefore, it is important for the management of SC to maintain high levels of satisfaction for both shopkeepers and consumers, and that this is done efficiently. In the life cycle of a SC, maintenance takes a leading role in building high performance and requires that in the early stages of design, maintenance management is taken into account. The performance of commercial centers and their components depends to a large extent on the continuous periodic maintenance, based on a well structured maintenance program. While more and more there is a need to reduce operating costs, management should also ensure that the facilities are built and maintained efficiently, without compromising security. This study describes the implementation of a methodology for evaluating the performance of a SC as a whole. The methodology will give us an indication of the condition of the building components and systems, as well as a key performance indicator to monitor the performance of the building and consequently the efficiency of the maintenance team.

REVIEW OF BUILDING EVALUATION METHODS

The literature review illustrates the need for Key Performance Indicators that allow analysts to assess the performance of buildings and that also can be used in facilities management and maintenance. Such indicators can support the monitoring of performance and provide a basis for additional indicators in the assessment of maintenance and quality of services in this area. However, it appears that there is a dilemma in the choice and development of assessment methods resulting from the need of a compromise between the complexity of research and the quality of results. Most researchers in this area follow the idea that an adequate assessment can be achieved by minimizing the cost of resources and time requirements. Some approaches use statistical techniques to reduce the scope of the survey [1]. Another approach, which is employed in projects requiring rehabilitation or renovation of buildings, focuses on the diagnosis of deterioration and employs statistical tools, quantitative and analytical, which are used by specialists from different disciplines involved in the assessment [2].

Another evaluation model used in the renovation of military sites [3] is based on three functions:

1. Physical parameters,
2. Functional parameters such as geometry, security and system compatibility, and
3. Location of facilities and peripheral infrastructures.

Mailvaganam and Alexander [4] developed an easy to use multi-stage repair activities processing model, which is based on an assessment of the building.

Shen and Lo [5] developed a system of cumulative points, which ranks buildings according to the assessment of priorities for renewal. This methodology analyzes three criteria:

1. the physical condition of the building;
2. the importance of the building function and
3. the influence exerted by its users.

Each building is given a score for each criterion. The specific scale for each criterion depends on the relative importance defined by the evaluator. For example, the scale related to the physical condition of the building can vary between 1 and 10, whereas the scale used to record the importance of the building function can vary between 1 and 5. This means that the weight of the physical condition is twice the building function. The final score is the sum of the scores for each criterion. This method is suitable for setting priorities, but cannot be used for an economic evaluation of maintenance costs.

Spedding et al. [6] [7], from the University of the West of England, developed a method called Multi-Attribute System. This method is based on a comprehensive study of different methods for the determination of maintenance priorities. The study involved a number of projects implemented by local authorities in England and Wales. Six criteria were chosen to determine the priorities for maintenance, as follows:

1. indispensability of the building, or the lack thereof;
2. physical condition of the building;
3. importance of the facility's use;
4. resultant effect on the users;
5. resultant effects on structures and
6. Effects on service provision.

The relative weight of each criterion C_i is W_i, and for each job j, is given a score (S_{j1}, S_{j2},…, S_{jn}. The priority index (or total score), S_j, can be calculated using Equation 1:

$$S_j = S_{j1}*W_1 + S_{j2}*W_2 + ... + S_{jn}*W_n \quad (1)$$

The process of criteria ranking and weighting can vary among different users. The scores for the criteria above were collected and used to rank projects on a relative scale, in descending order.

Caccavelli and Gender [8] developed a methodology to summarize the current condition of a building and estimate the cost of various works, as well as the need to renew, with regard to energy conservation. The methodology is composed of 50 elements, between one and six element types, and four codes per type. Each element is classified according to the following category code:

1. in good condition;
2. slight degradation
3. medium degradation;
4. poor condition (requires replacement).

Allehaux and Tessier [9], applied quality criteria to determine the functional obsolescence of electromechanical systems in office buildings.

Pullen et al. [10] defined seven KPIs to assess the maintenance service in Australian hospitals. Most of them were business oriented. However, the performance of the building was not included in any of them.

McDougall and Hinks [11] indicated that the economic and financial indicators are neither sufficient nor satisfactory for the analysis of performance management of facilities once the performance aspects of building are not integrated in these indicators.

A joint research conducted by the CSIRO and Queensland University of Technology have developed a prototype model to facilitate decision making on the sale, maintenance, and review the building portfolio. The model includes two main indicators: Property Standard Index (PSI), and the Hold/Sell Index [12] (O'Shea et al., 2000). The PSI is based on a number of factors related to the physical condition of the building, its age, and construction standards for new residential buildings [13]. The model was tested and deployed in a large number of houses owned and maintained by the Queensland Department of Housing. The PSI provides an indicator that shows the potential impact of resource allocation on the general condition of the building, and economic feasibility of corrective maintenance [14].

RESEARCH OBJECTIVES

The main goals of this study are:

1. Present the implementation results of a KPI through a systematic approach, which enables the assessment of maintenance efficiency in a shopping center. The assessment will be based on the performance of building components by uniform criteria.
2. Establish a measurement system for the assessment of the building. This system will reflect a comprehensive view of building performance.
3. Provide systematic indicators to prioritize maintenance activities.

The model we use in this study [15] was implemented in public hospitals in Israel. Given the similarity between the types of buildings (hospitals and shopping centers), it is also our aim to show that this methodology is valid for shopping centers.

RESEARCH METODOLOGY

The implementation of the methodology includes an assessment of the conditions of the building during the maintenance process.

This assessment considers the following aspects:

1. Evaluation of building structure in relation to planned loads;
2. Evaluating the adequacy of existing spaces within the building face to the current use (eg. number of daily customers/m^2);
3. Assessing the suitability of finishing materials, interior and exterior (doors, windows, exterior finishes duration measured by its rigidity, waterproofing, leaking).
4. Assessing the suitability of electromechanical systems (capacity of the switchboards, HVAC system, fire fighting system, etc.).

In terms of building systems, this methodology includes:

1. Structural elements (columns, beams and slabs)

2. External envelope (external walls and roofs)
3. Interior finishing (doors, walls, ceilings and floors)
4. Electrical systems (switchboards, switchgear and cables)
5. HVAC (Circulator pumps, chillers, fans, air handling units, cooling towers, etc.)
6. Fire detection and fire fighting (automatic fire detection and fire fighting, sprinklers, fire detectors, fire panels, etc.)
7. Communication and surveillance systems (closed circuit television, telephones, etc.)
8. Lifting and handling systems (elevators, escalators and passenger conveyors)
9. Water and waste water systems.

To implement the methodology two major phases have been defined:

a) The first, entitled "Facility Characterization", which concerns the identification and collection of parameters and information related to the various systems and building components. The required information includes the drawings of the office facilities, buildings, history of construction, maintenance work carried out and records of maintenance activities;

b) The second stage involves a technical visit to the building, based on the analysis of the information gathered in the first phase;

We used a method of analysis that examines the building using criteria that reflects different aspects of building performance. The assessment is conducted using a matrix for assessing the nine systems mentioned above.

BPI – BUILDING PERFORMANCE INDICATOR

The Building Performance Indicator monitors the physical condition and fitness for use of the building and its various systems, based on quantitative criteria. Each of the building systems (structural elements, exterior envelope, interior finishes, electrical systems, HVAC systems, water supply and wastewater systems, detection and fire fighting, surveillance and communication, and systems to lift and transport) is rated on a performance scale of (0-100), expressing their physical and functional condition (P_n).

The value of BPI reflects the performance level of the building: when BPI>80, the condition and performance are good or reasonable, 70<BPI≤80 indicates the building condition is such that some systems are in marginal condition (some preventive maintenance actions should be taken), 60<BPI≤70 reflects deterioration of the building (some corrective maintenance actions should be taken), and BPI≤60 means that the building is deteriorated.

Global BPI is obtained by adding the performance values of each system. The condition of the building is assessed according to three criteria: (1) current condition of physical systems, (2) frequency of system failures and (3) current preventive maintenance and visual inspections that are carried out. Table 1 shows the evaluation values of each component.

The weight of internal components of each building system is divided into three categories: (1) physical performance, (2) frequency of failure and (3) implementation of preventive maintenance and periodic inspections.

Shohet [16] indicates that the weights are determined based on partial assessments of the needs for manpower and equipment for periodic maintenance and failure costs. The weight distribution is presented in Table 1.

Building System	Weight of physical performance and failures	Weight of periodical maintenance
Structural elements	90	10
Interior finishing	70	30
External envelope	75	25
Fire detection and fire fighting	75	25
Communication and surveillance	50	50
Lifting and handling	60	40
Electrical	50	50
HVAC	50	50
Water and waste water	75	25

Table 1 - Weight distribution (%) in each building system.

Source: Construction Management and Economics (October 2003)

In the case of structural elements, for example, 90% of the weight assigned to the physical performance and to the category of failure frequency, reflects a low need for maintenance of the structural elements compared with the impact of failures in these elements.

The classification system for each P_n is expressed on a scale of 0-100, and is given by Equation 2:

$$P_n=C_n*W(C)_n+F_n*W(F)_n+PM_n*W(PM)_n \quad (2)$$

The classification comprises three aspects concerning the maintenance of the facilities:

1. actual condition of the system - C_n
2. failures affecting the service provided by the system - F_n
3. actual preventive activities carried out on the system to maintain acceptable service level - PM_n.

Where:

$W(C)_n$ = weight of component condition of system n

$W(F)_n$ = weight of failures in system n

$W(PM)_n$ = weight of preventive maintenance for system n

For every system n, the sum $W(C)_n+W(F)_n+W(PM)_n = 1$

The value of Cn is obtained based on a scale of 100 points, where 100 expresses the total performance score, 60 in damage and 40 and 20, failure and poor performance, respectively.

Preventive maintenance PM_n is evaluated based on the existence of a preventive maintenance plan and its implementation frequency.

Frequency of failure F_n is assessed on a scale between 100 – no failures in 12 months, and 20 - occur frequently (e.g., occurring 12 times in the last 12 months).

The combination of these three elements represents the performance score of the entire system, P_n.

The weight of each building system, the W_n, is determined by Equation 3:

$$Wn = \frac{\sum_{j=1}^{m}(R_{nj} + M_{nj} + C_{nj})}{\sum_{n=1}^{9}\sum_{j=1}^{m}(R_{nj} + M_{nj} + C_{nj})} \quad (3)$$

$$\forall_n = 1,2,...,9$$

Where:

n = Index of building system

W_n = Weigth of the *nth* building system (structure, exterior envelope, etc.)

j = Index of component in system j (e.g. pumps, fans in HVAC system)

m = Number of components in building system

R_{nj} = Replacement cost of component j in system n at the end of its predicted life cycle

Shohet (2003) assume in his model, that a component is replaced only if the remaining service life of the building is greater than 0,5 of its life cycle.

M_{nj} = Annual maintenance costs of component j in system n

C_{nj} = Reinstatement value of component j in the *nth* building system

BPI can be calculated using Equation 4:

$$BPI = \sum_{n=1}^{9} P_n * W_n \quad (4)$$

Where:

BPI = Building performance Indicator (0-100)

P_n = Performance level for system n (on a scale of 0 to 100)

W_n = Weight of system n in the BPI, as determined by Equation 3.

RESULTS

The implementation of this methodology to the SC of our study results in an overall BPI of 89, which represents a state of good performance.

“Structural elements” is the system with better performance with a high physical and functional condition. Its corresponding value of P_n=95 is mainly due to the quality of construction and maintenance actions. This system has a significant weight on the overall performance of the entire building. At the other end, the “Means of lifting and handling” system has a weak performance with a P_n=78. This situation is mainly due to high utilization of the equipments and shows that this level of use was not considered in the design phase.

In other systems, the results show an equilibrium which is justified by the performance of maintenance and service outsourcing, as well as the planned replacement of components in each system at the end of their life cycle.

CONCLUSION

Assessing the state of buildings is highly important to the success of any maintenance and rehabilitation program through a management indicator. The evaluation methodology presented in this paper aims to provide an objective and systematic method for the analysis and assessment of buildings before the execution of maintenance activities and rehabilitation. The methodology uses scales for assessing the performance of building components. The condition of the building is assessed by the BPI.

The method allows the determination of priorities based on the performance of the entire building (BPI), and performance of each building system. The BPI represents a KPI for the performance assessment of buildings and can be extended to generate KPIs for the evaluation of resources and efficiency of maintenance operations.

Despite the advantages, the methodology, however, requires a thorough understanding of the scales used for each building component. The methodology also requires a thorough field research to avoid errors in critical components, such as structural components or fire protection system.

This methodology generates quality and quantity indicators of management for the following purposes:

1. Evaluate the general condition of systems in a particular building.
2. Assess the condition of a system of a particular building during the assessment. For example, BPI allows the identification of components with a consistent tendency to be in poor condition.
3. Provide a comparative measure for the definition of priority in the allocation of resources (financial, labor and materials).
4. Allow for benchmarking between multiple buildings.

In the future, this methodology should be applied to a greater number of shopping centers in order to understand the behavior of systems that are similar, but differ in size and in maintenance philosophies. Energy consumption, not included in BPI, should be investigated to generate a new indicator of energy performance of each specific component and system and the building as a whole.

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BENCHMARKING ON BEHALF OF MANAGEMENT SYSTEMS INTEGRATION

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Abstract: The integration of management systems, to be effective, requires several organisational features. An integrating concept enabling a common language, a proactive approach, a holistic vision, sustainable objectives and consistence and coherence on action are among those features. All these features will be properly and efficiently achieved considering concepts linked to benchmarking, namely, teammanship, self-management, democracy in management and collaborative benchmarking. This paper is based on an ongoing research project focusing the development of a tool/methodology to assess maturity and effectiveness levels achieved by organizations that implemented an integrated management system (IMS) being its purpose to report and to enhance the potential synergies between benchmarking methodologies and management systems integration. The research, and implicit results, aims organizations that are considering an IMS implementation being the findings transferable to *in field* environment, being useful to practitioners willing to implement an IMS.

Keywords: management; integration; organisation; benchmarking

INTRODUCTION

We (all) are living times of changing... Concepts old time established are being shaken and, either, voluntary or compulsory updated and revised. 'It is a competitive world; everything counts in large amounts' [1]. Organizations mirroring these sociological and cultural events face themselves under strategic challenges. Several reported studies predicted and felt this industrialisation to post-industrialism organisational change previously, and [2] to [13] are some examples from those studies.

Following Quality Management System (QMS), organizations proceeded with the implementation of several sub-systems addressing different stakeholders and requirements. The main reported sub-systems "inhabiting" in an integrated approach are QMS, Environmental Management System (EMS) and Occupational Health and Safety Management System (OHSMS). This newly organisational environment arouses and promotes interactions never experienced by strategic management responsible [14], [15]. Traditional management indicators, if suitable, allow mainly a discrete assessment from the integrated management system (IMS) status. The precise description of effectiveness and maturity levels achieved by an IMS should rely on a continuum based interactions assessment due to the following reasons and facts:

- Dimensions increase on a generic system requires new variables to be assessed in order to completely describe newly existing status from the system.
- Similar to the intrinsic differences among vector and scalar quantities in an integrated environment the complete system status description is not possible based on a unique variable or dimension, and should be supported on dimensions identification, variables definition and on interactions assessment between *inputs/outputs* originated or derived from each management sub-system. This issue had been addressed by Domingues, Sampaio and Arezes [16]. Additionally the authors proposed a potential path for interactions assessment.
- Currently, top management should address stakeholders' requirements as well shareholders requirements (Fig. 1). This new focus orientation, repositioning organization role on the society, asks for a top management *inside out* perspective.

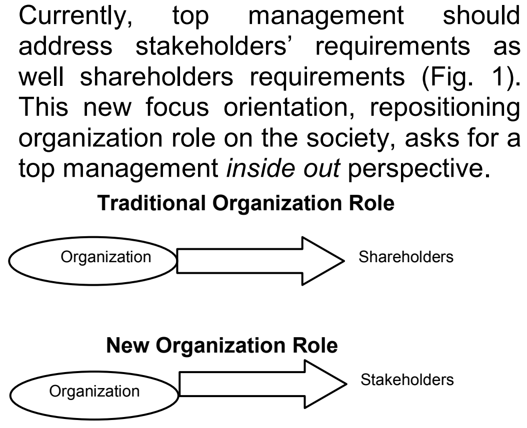

Fig. 1 - Traditional *versus* New organization role on Society (Source: authors)

Benchmarking proved itself as a suitable tool for measuring competitiveness [17], methodology for quality function deployment [11], [18], key performance indicators definition and assessment [19], performance measurement during strategic change [20], innovation adoptions [21], critical factors for TQM definition [17], [22], efficiency usage of nodes in clusters determination [23] and in medium and small internal audit units [24]. Cutting edge management concepts have been focused also by the most prestigious journals on benchmarking and conceptually associated with it. Teammanship as a viable alternate methodology to leadership [25], self-managing teams supporting quality and/or technology management [26], democracy in management [2], sustainability and synergistic relationships [8], [27], six-sigma benchmarking [28], collaborative benchmarking [5], product development assessment [29] and knowledge management [30] are among those concepts.

SURFING THE BENCHMARKING WAVE

Benchmarking concept has been labelled and badge, for too long, as a "minor" scientific and operational principle. Currently, and more than ever, the search and urgency for better performances within industrial or organisational processes is a critical feature focusing success. A set of rather generic potential strategies within simultaneously co-existing management sub-systems was identified earlier [31]. Those strategies, diffusively present even at the IMS genesis, are: the divide et impera, the concordia discors approaches and the rather naïf e pluribus unum approach. A deeper interpretation and analysis of management systems integration should be involved on a philosophical "misty scent". Holism has been defined as a conceptual theory stating that '…parts of a whole are in intimate interconnection, such that they cannot exist independently of the whole, or cannot be understood without reference to the whole, which is thus regarded as greater than the sum of its parts' [32]. In opposition to reductionism or atomism, holism takes into account inherently, an often "forgotten" feature from a generic studied system: interactions. Even the purists from the exact sciences, with an intellectual genetic aversion to holism embrace it elegantly and with a "Mona Lisa smile", when defining "black box" phenomena.

The surge of interest in the transfer of private sector management practices to the public in the past decades [5], including benchmarking, illustrates the wide context were these ancient methodologies may reborn and prosper.

Looking out for techniques enabling quality improvement and rating an organizational performance against the World's Best Class are the ultimate objectives of benchmarking methodologies [17], [33]. Several authors subscribed the opinion expressed by Sink (1993) that the overall performance of an organization is defined by seven criteria [2]:

- Effectiveness.
- Efficiency.
- Quality.
- Productivity.
- Quality of work life.
- Innovations.
- Profitability.

This rather narrowed and introspective vision on organizations role is now being challenge. These defined criteria seem to be insufficient by themselves when considering concepts like sustainability, gender equity, social accountability, globalization and knowledge management.

BENCHMARKING AND IMS

As stated earlier, a major wake up call on organizations self-awareness has rang. At the present, several stakeholders' requirements should be met by organizations: quality, environmental, occupational health and safety, social responsibility and gender equity are among those requirements. Management systems integration may be faced, currently, as an organisational "earthquake" releasing tensions derived from this newly reposition of organizations in the society. Some organizations stood up firmly while others collapsed. Like in severe nature phenomena, organizations were scarcely prepared and after the "organisational dust settlement" it is time to rebuild. Prior bad and good management sub-systems performances and practices should be taken into account in order to achieve successfully organizations New Order, being benchmarking within management sub-systems, more than a viable alternate methodology but, a desirable central operational philosophy to accomplish this feature. Related to organizational management sub-systems, considering the latest available data from ISO Survey [41], it seems that organizations optioned by the 'Together we stand, divided we fall' [34] approach, that is, the integrated approach.

In 2002, Wilkinson and Dale [35] identified five key issues regarding management systems integration based on available literature and integration models at the time. These issues were:

- Integration ways, levels and term definition.
- Compatibility.
- Sub-systems scope.
- Total quality approach.
- Organizational culture.

Benchmarking and the integration of management or operational practices have been recently linked and reported in several papers [36] - [39]. Braadbaart [5] stated that 'benchmarking has the potential… to enhance organizational efficiency and effectiveness for organizations…', which is too, an objective envisaged by management systems integration. Currently, a major open issue related to IMS is under management systems community attention. IMS effectiveness and maturity level assessment, which is, an implementation performance measurement, is not properly assessed due to the lack of tools or methodologies [40]. Performance measurement has been focused by Feurer and Chaharbaghi [20] stating that a suitable performance measurement system should comply with the characteristics enumerated on Table 1.

Table 1 - Suitable and desirable characteristics for a performance measurement system (adapted from [20])

1	Evaluation of the internal and external environments of an organization.
2	Determination of the underlying causes behind the existing situation together with their interrelationships.
3	Identification of future trends and their implications to the organization.
4	Identification of organization goals in order to determine where to be in the future.
5	Knowledge acquisition regarding the relationship between action and goals.
6	Definition and communication of the new objectives throughout the organization.
7	Alignment of operations and supporting objectives for instituting a common purpose.
8	Development of a system for rewarding achievements which acts as a catalyst for motivating future change.

In an integrated management system, each management sub-system adds peculiar features intrinsically linked to its own nature. Despite the common structure (Deming cycle), the major add value to achieve under an integrated context should be the benchmarking of these features by other management sub-systems. Fig. 2 illustrates these desirable peculiar features from each management sub-system.

Desirable "Benchmarkable" features from QMS, EMS and OHSMS

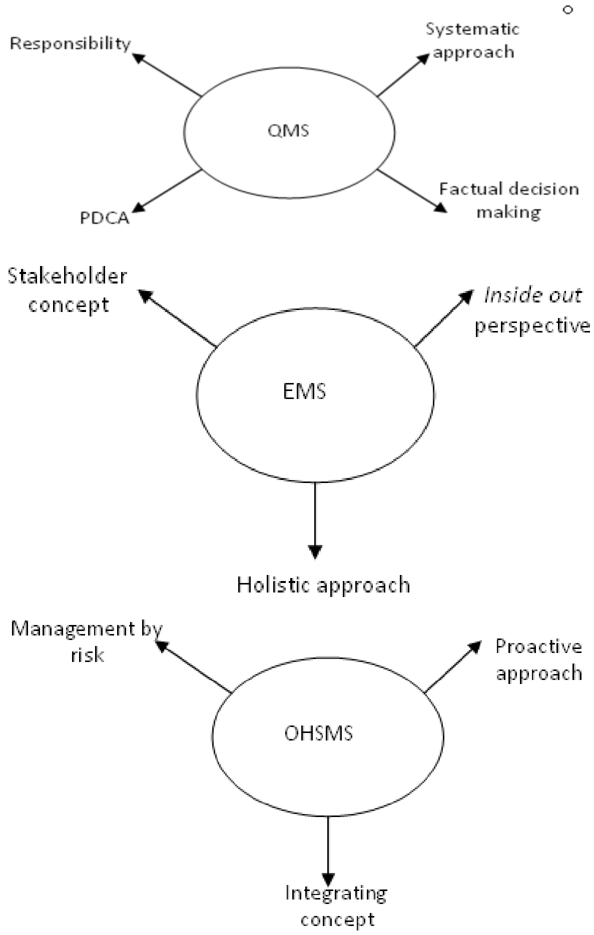

Fig. 2 - Benchmark features from each management sub-system (Source: authors)

CURRENT STATUS ON MANAGEMENT SYSTEMS: THE ISO SURVEY DATA

Information provided by last issued ISO Survey [41] suggests that ISO 9001 is acting as a benchmark to other referentials, providing a sustained ground and enabling the implementation of other organisational standards, focusing new requirements and stakeholders.

Based on Tables 2 and 3 we are able to conclude that, with honourable exceptions, the mostly involved countries on ISO 9001 certification are also involved on ISO 14001 certification. An integrated analysis of both ISO 9001 and ISO 14001 data suggests the following conclusions:

- China, Japan, Italy, Spain, UK, Germany, USA and Republic of Korea are deeply involved on both ISO 9001 and ISO 14001 certification.
- India is mostly involved on ISO 9001 certification.

- Romania and Czech Republic are mostly involved on ISO 14001 certification.

Tables 2 and 3 - Top 10 countries for ISO 9001 and ISO 14001 certificates

Table 2- ISO 9001	
1	China
2	Italy
3	Japan
4	Spain
5	Russian Fed
6	Germany
7	UK
8	India
9	USA
10	South Korea

Table 3- ISO 14001	
1	China
2	Japan
3	Spain
4	Italy
5	UK
6	South Korea
7	Romania
8	Germany
9	USA
10	Czech Rep.

Tables 4 and 5 illustrate that, currently, the most ISO 9001 and ISO 14001 active countries are China, Japan, Italy, Romania and Russian Federation.

Tables 4 and 5 - Top 10 countries for ISO 9001 and ISO 14001 certificates growth

Table 4- ISO 9001	
1	Russian Federation
2	China
3	Italy
4	Japan
5	Romania
6	Czech Republic
7	Viet Nam
8	Poland
9	Israel
10	Iran

Table 5- ISO 14001	
1	China
2	Japan
3	Romania
4	Hungary
5	Italy
6	United Kingdom
7	Czech Republic
8	France
9	Thailand
10	Russian Federation

It should be mentioned that Tables 2 to 5 rely on raw data not being weighted by demographical or macro economical parameters.

Table 6 shows that the same top 3 industrial sectors are involved both on ISO 9001 and ISO 14001 certification.

Table 6 - Top 5 industrial sectors on ISO 9001 and 14001 certificates

	Top five industrial sectors for ISO 9001 certificates 2009	**Top five industrial sectors for ISO 14001 certificates 2009**
1	Construction	Construction
2	Basic metal & fabricated metal products	Basic metal & fabricated metal products
3	Electrical and optical equipment	Electrical and optical equipment
4	Machinery and equipment	Wholesale & retail trade; repairs of motor vehicles, motorcycles & personal & household goods
5	Wholesale & retail trade; repairs of motor vehicles, motorcycles & personal & household goods	Rubber and plastics products

Figures 3a and 3b analysis suggests that both ISO 9001 and ISO 14001 certified organizations are increasing worldwide. If the saturation level has been reached (Figures 3a and 3b), namely on the number of ISO 9001 certifications, is still an appealing, lingering, open and active discussion among management system community at the moment.

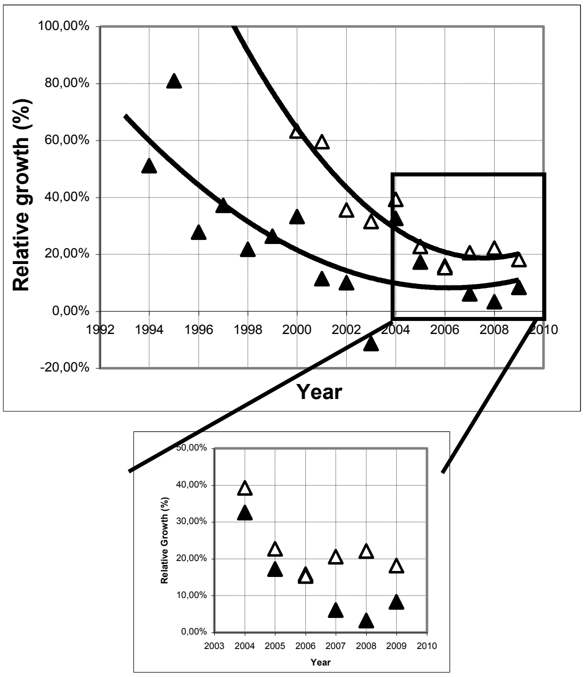

Fig. 3 a,b - Relative ISO 9001 and ISO 14001 growth

The time evolution of demographical weighted data (number of certificates per 1000 inhabitants), presented in Figure 4 and the ratio between ISO 14001 and ISO 9001 number of certificates (Fig. 5), shows that the number of ISO 14001 issued certificates is increasing more than ISO 9001 issued certificates.

Nevertheless objective data over IMS are not provided by ISO. Hence, the increase on both ISO 9001 and ISO 14001 certified organizations, certainly also implies an increase on IMS.

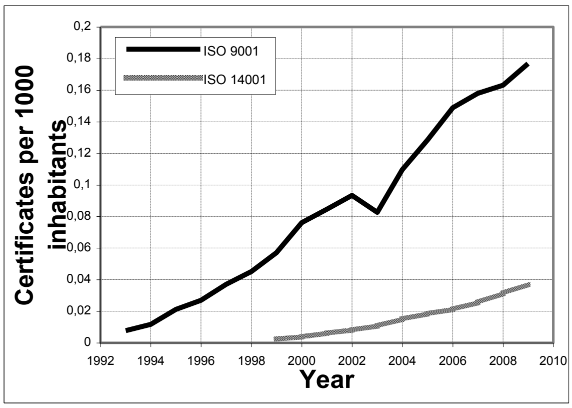

Fig. 4 - ISO 9001 and ISO 14001 certificates per 1000 inhabitants (worldwide)

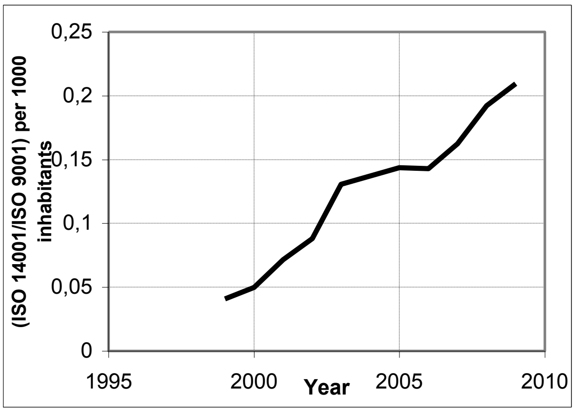

Fig. 5 - ISO 14001 to ISO 9001 certificates per 1000 inhabitants ratio (Worldwide)

Figures 6 and 7 illustrate the time evolution (1999-2009) of ISO 14001 to ISO 9001 ratio among several countries in Europe. We may conclude that this ratio has increase in all selected countries suggesting an increase on IMS.

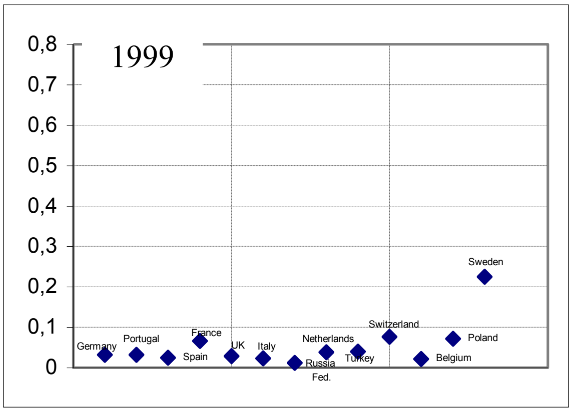

Fig. 6 - ISO 14001 to ISO 9001 certificates per 1000 inhabitants ratio in 1999 (Europe)

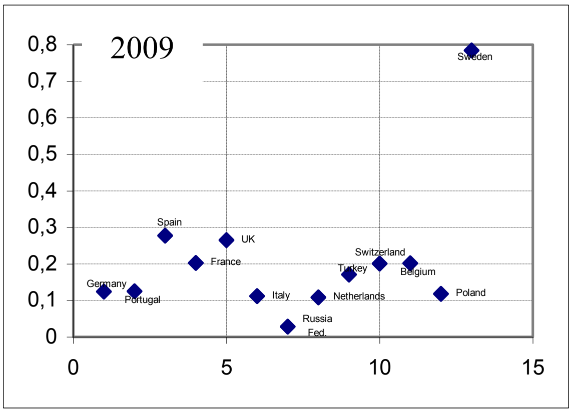

Fig. 7 - ISO 14001 to ISO 9001 certificates per 1000 inhabitants ratio in 2009 (Europe)

QUID PRO QUO

The benchmarking concept is understood (still) to be an act of imitation and copying [33]. The above mentioned on the present article has mainly been focused on which features could be enhanced in management systems integration by adoption of benchmarking methodologies. If we look around, Nature tell us that symbiotic relations are more sustainable, addressing several 'stakeholders' requirements by establishing mutual advantageous interconnections. Potential benefits for management systems integration were discussed and exposed. So, the ultimate main question raised by the appliance of benchmarking methodologies through management systems integration is:

Which are the expected benefits for the benchmarking concept?

Conceptual reborn and elevation to a proactive philosophy degree may be expected on benchmarking concept after a symbiotic relationship with IMS. Recalling the currently "Hall of Fame" of management practices or concepts, namely, TQM, QFD, Deming cycle, Six-sigma, EFQM and Risk Assessment we may see how these concepts prevailed until our days. Benchmarking on behalf of management systems integration would guarantee to benchmarking concept a deserved place among these honourable concepts.

FINAL REMARKS AND CONCLUSIONS

- ISO 9001 is, in our days, a benchmark pursuit by other management referentials.
- Based on the latest ISO Survey, the number of integrated management systems is increasing worldwide. Objective data should be provided in order to quantify this assumption.
- Each management sub-system has their own fingerprinted "genetic" features that, desirably, should act as benchmarks for other management sub-systems. The systematic approach, factual decision making, responsibilities accountability and the PDCA cycle are inherently linked to Quality Management sub-system. The stakeholder concept understood under a holistic and inside out perspective is properly expressed by the Environment Management sub-system. The proactive approach and management by risk assessment, acting risk as a potential integrating factor enabling a common language are intrinsic characteristics from the Occupational Health and Safety Management sub-system.

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PERFORMANCE AND RISK ASSESSMENT FRAMEWORK FOR SUSTAINABLE NETWORKS

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Abstract: Nowadays, supply chains and specially Collaborative Networks are increasingly aware of sustainability issues and continuously seek to meet current human needs while preserving the environment so that these needs can be met not only in the present, but for future generations. In order to achieve this goal, particularly within Collaborative Networks, present decision making related with sustainability policies and practices, becomes a critical issue for the future of each stakeholder in the network. Sustainability networks must ensure that economic, environmental and social axes are fully aligned within each partner. To accomplish this, "performance metrics" for the entire network are required not only concerning the economic value of a business, but also in its environmental and social impacts. In line with this concept, organizations need to improve the quality of performance assessment namely in the sustainability areas. This paper focuses on this topic, presenting a new approach for performance and risk assessment within sustainable networks.

Keywords: Collaborative Networks; Performance Management; Performance Assessment; Risk; Key Performance Indicators; Sustainable Performance Indicators.

INTRODUCTION

Sustainability is defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'[1]. According to the UN 2005 World Summit it was noted that sustainability requires the reconciliation of environmental, social and economic demands - the "three pillars" of sustainability.

Particularly within Collaborative Networks (CN), present decision making related with sustainability policies and practices, is a critical issue for the future of each stakeholder of the network. Sustainability networks must ensure that economic, environmental and social axes are fully aligned within each partner.

Due to this pressure from stakeholders, "performance metrics" for the entire network are required not only on the economic value of a business, but also in its environmental and social impacts. In the context of CN, the performance metrics evaluation represents an important management challenge due to the heterogeneity present in the networks. Nevertheless, if successfully implemented, performance and risk assessment enables network managers to create enduring value for the multiple stakeholders in the network.

Increasing numbers of organizations report a massive volume of data, with low consistency and high variability in data quality, making it necessary to develop and implement new approaches for CN sustainable performance assessment. In line with this, organizations need improve the quality of performance assessment for the sake of both internal and external decision making.

This paper focuses on this topic, presenting a new approach for performance and risk assessment within sustainable networks.

PERFORMANCE MANAGEMENT

According to Sobotka and Platts [2], it is not possible to manage a process if we cannot measure its performance. In other words, performance management should be seen as an essential principle of management, because it not only enables the detection of gaps and bottlenecks in the processes (matching between current performances and desired performance), but also indicates where processes should be improved, namely in the sustainability issues, in order to fulfil these gaps and increase the overall performance of the factory or the entire supply chain. Hence, for sustainable companies, it is critical to determinate and select the key performance indicators, which, delivered to the right decision maker, can provide the crucial information to assure the factory processes improvement.

In fact, to achieve a useful performance management, it is required to the managers perform an exercise of balance between the interests of the supply-chain participants, knowledge about costumer's requirements, environmental factors and the business processes knowledge. Indeed, the choice of performance measures (economical, environmental and social) not only must integrate strategies, resources and processes but also should allow the its continuous improvement. In fact, this choice enhances the company to become more flexible and capable to adapt in real time to the continuously changing market and social demands.

Key Performance Indicators

In order to execute a performance analysis of a complex system, a preliminary step requires the structuration of the raw data available on the company. As result of this process performance indicators are generated. However, not all performance indicators are relevant to the system behavior analysis. It is necessary from the managers to define which are the key indicators to use according to their importance for the process. The key performance indicators (KPIs) are the input information to be analysed once captured by a performance measurement systems on the processes' output. The results obtained from this evaluation intends to be able to provide reliable information for decision making referring the necessary actions to problem solving, continuous improvement, process reengineering, or process innovation. In fact, the KPIs should be selected in order to support decision-makers improve the performance of processes in focus [3]. A linked concept is the key results indicator (KRI); which represent how actions are done in a perspective of a critical success factor. Other related concepts are the results indicator (RIs), or outcomes, that tell us what has been done; and the performance indicators (PIs), that tell us what has to be done. So, according to Parmenter, the KPIs "represent a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization".

The indicators establish the background foundation for understand the performance measurement and management system of an organization in its different perspectives. Firstly, it is important to define the performance management process regarding the information and data obtained from the performance measurement. Therefore this process comprises five stages: process output results, measurement inputs, results evaluation, decision making and improvement actions. In figure 1 it is represented the activities that can be related to each stage in order to execute the performance management process.

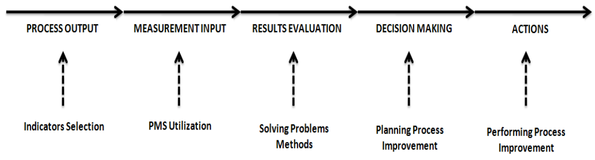

Fig. 1. Performance Management Process and correlated activities

In practice, activities such as selection of indicators, use of performance measurement system, solving problems through methods, improving the planning processes and improving the implementation of processes lead to achieving a better performance management cycle.

According to Franceschini, Galetto and Maisano [4], the indicators selection should be performed considering whether the results of the processes meet the needs of stakeholders, through an assessment system to test this condition. These indicators selection supports the decision to which strategies will be taken namely related to sustainability issues.

In order to define KPIs that meet sustainability issues, consumer expectations, regulation standards or goals to the organization, it is appropriate to use the process definition from ISO 9001: 2008: "an integrated system of activities that uses resources to transform inputs into outputs" (Franceschini, Galetto and Maisano, 2007, referring ISO 9001:2008 [4]. Adapting this description to the KPIs process definition and replacing the term "resources" to "requirements", it is possible to design a framework based on IDEF standard [5](Michel, 2002) to direct the definition and choice of KPIs. In the Figure 2 the modelling function IDEF0 is presented for the KPIs definition.

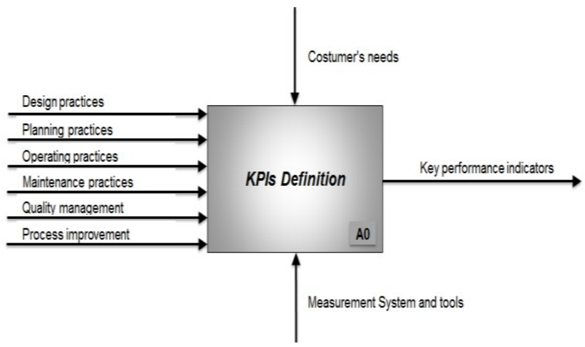

Fig. 2. KPIs definition through process concept

Sustainable Development

Making the concept of sustainable development operational for Collaborative Networks bring up important challenges in terms of measurement and assessment. Without indicators or a quantitative framework, CN decision makers seeking sustainable development policies inside the network lack a solid foundation on which to proceed.

As stated previously, the concept of sustainable development includes three dimensions: economic, environmental and social. Yet according to Candice Stevens [6], between these three dimensions there are complex synergies and trade-offs among them (see Figure 3).

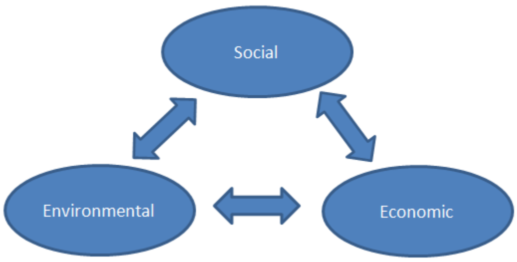

Fig. 3. Key dimensions of sustainable development [6]

Included in these synergies and trade-offs among the CN surroundings it is possible to identify the following effects:

1. Effects of economic activity on the environment such as resource consumption, waste volumes and pollutants discharge.

2. Effects of economic activity on society such as economic growth, income levels, employment and support for social services.

3. Environmental services to the economy such as provision of natural resources, sanitary landfills, contributions to economic efficiency and employment, human resources technological training.

4. Environmental services to society such as access to resources and facilities, contributions to health, quality working and living conditions.

5. Effects of social aspects on the environment such as environmental education, demographic changes, consumption patterns and environmental awareness.

6. Effects of social aspects on the economy such as labour force, population and residential structures, education and training skills.

To proceed towards sustainable development, companies and specially CN seek to follow policies aimed to increase economic efficiency and material wealth usage in order to take into account social and environmental objectives. Clear in this concept is a focus on inter-generational equity, implying that future generations should have same opportunities to those now available.

There is a consensus that sustainability indicators are needed to evaluate the longer-term implications of current decisions and behaviours from managers and to monitor progress towards sustainable development goals.

In simple terms and concerning an inter-firm view from the economic perspective, sustainable growth is the realistically attainable growth that a company should keep in order to maintain the risk in a controllable range, without achieve a no-return point. Indeed, a business that grows too fast may find it difficult to fund the growth while a business that grows too slowly, or not at all, may stagnate and cease to be competitive.

Therefore, one of the main challenges becomes finding the optimum Sustainable Rate (SR). This is the maximum growth rate that a company can sustain without having to increase financial leverage without affecting the environmental and social dimensions. In summary, in order to find a company's SR, it is primarily necessary to respond to the following question: how to measure and manage a single company and/or collaborative network growth in a sustainable way?

Despite the importance that this issue represent for the nowadays companies, achieving this goal is not an easy task, given the rapidly changing political, economic, market competitiveness. In fact, each of these areas presents unique challenges to business managers searching for the elusive grail of sustainable growth.

Moreover, CN stakeholders contend that achieving the excellent SR is not possible without take into consideration two main internal aspects: growth strategy and growth capability. Companies that pay inadequate attention to one aspect or the other are destined to failure in their efforts to establish practices of *sustainable* development (although short-term gains). After all, if a company has an excellent growth strategy in place, but has not committed the necessary resources to execute that strategy and have not considered the social and environmental dimensions, long-term development is unachievable. The reverse is true as well.

Therefore, due to the enormous quantity of information available for each of the sustainability dimensions, it becomes essential to select the critical data that helps decision makers to make the right decisions. Thus, we can define these critical data after processing as Key Sustainability Indicators (KSI).

Although the heterogeneous nature of the different companies within CN, network managers, are forced to define a global and homogenous strategy coherent for the entire network. Based on this premise, the KSI must be selected according to the overall strategy and applied to the entire network.

In sum, the definition of a sustainable development model goes together with the selection of the relevant KSI. This concurrent approach is particularly helpful in guaranteeing the system monitoring, while managing its sustainable development. Therefore, the implementation of a detailed, extensive and well-fitted sustainable development model becomes a crucial tool in order to reduce the risk impact of present decision in a medium and long term.

Yet simple and easily-understood indicators that do not compromise the underlying complexity of sustainable development have been difficult to define. Measuring sustainable development requires both simple measures that inform network decision-makers about relevant performance factors but also more detailed measures to support in-depth analysis. It is also important to have a double perspective about these measures, by given attention not only to the “supply side” (how statistics and related indicators can best be constructed) but also to the “demand side” (how these indicators can be translated and used most appropriately).

RISK ASSESSMENT

During the entire life cycle of Collaborative Network, it is necessary to not only to monitor the overall performance behaviour and sustainability development but also to analyze and assess the risk posed by the decisions made by the different stakeholders.

Indeed, a risk assessment program must be more proactive than reactive during the entire Collaborative Network life cycle. A proactive risk assessment must influence the Collaborative Network design process before the process begins. This approach should incorporate safety features with minimal cost and social/environmental impact.

The concept of controlling risk is not new. Lawrence [7] in 1976 had discussed the topic. He stated that “a thing is safe if the risks are judged to be acceptable”. Recent discussions have focused with the risk associated with potential damage or degradation of system performance. Since risk is an expression of probable loss over a specific period of time, two potential variables, loss and likelihood can be considered as the control parameters. To control risk both the potential loss (severity or consequence) and its likelihood are addressed. A reduction of severity or likelihood will reduce associated risk.

As stated by Pecht [8], a critical and time consuming activity that must be performed from the inception of collaborative network business model is the risk assessment. Indeed, from the partner’s selection, throughout the external logistics and processes definition, till the CN operation, it is vital to evaluate and assess the risk linked to each decision.

From the risk analysis it is possible to achieve a series of goals regarding the sustainability development of Collaborative Network. Therefore it is important identify the actions that can be taken to guarantee the alignment of the three sustainable dimensions and keep high performance rates at long term periods.

In the context of a Collaborative Network risk analysis, it is fundamental to obtain and analysis quantitative values, including uncertainty, not only for each collaborative process but also for the entire network. Thus, the identification of the important contributors to uncertainty and their characterization presents an important add-value once it enables the identification of the potential risk reduction actions.

The risk assessment program results are directly related with the Collaborative Network life-cycle phase in which the analysis is performed. For example, a preliminary risk analysis should be completed at time to influence the partners selection and tasks allocation. Therefore, this preliminary risk analysis should be performed prior to the preliminary Collaborative Network design. The objective is to use risk analyses diagnosis in time to be beneficial for the CN managers decision-making. This risk assessment program is also important in order to the Collaborative Network achieve sustainable development.

SUSTAINABILITY INDEX FRAMEWORK

Frameworks are important to structure work on indicators and on underlying performance. Because sustainable development encompasses three different dimensions and their interactions, there is a vast range of relevant indicators requiring a reference model in order to be framed in an organised structure. A sustainability indicators framework should be simple and understandable so as to link the indicators to management decision and performance evaluation.

Following the approach presented earlier, it is now important understand how it is possible to develop a tool capable of merge the different dimensions of the Key Sustainability Indicators and calculate a global Sustainability Index.

Primarily, it is important for CN managers to understand that for each economical, environmental and social dimension implicitly there are more than one KSI. Secondly, due to the subjectivity and non-deterministic nature of most of these indicators a modelling difficulty arises. Therefore, presented this heterogeneous and ambiguity scenario it is adequate to use a Fuzzy Logic technology capable of analyse each of the key indicator and retrieve the assessment corresponding to each dimension. This fuzzy logic analysis can be performed through the use of the equation represented in figure 4. In the sustainability index fusion equation each of the vectors contain the real values measured for each of the KSI. This vectors are used as inputs for the fuzzy system that in turn will be responsible for its compilation.

$$[f_{Fuzzy}(KSI_{Econ}), f_{Fuzzy}(KSI_{Amb}), f_{Fuzzy}(KSI_{Soc})] * \begin{bmatrix} \begin{bmatrix} KSI_{Econ1} \\ KSI_{Econ2} \\ \dots \\ KSI_{EconN} \end{bmatrix} & 0 & 0 \\ 0 & \begin{bmatrix} KSI_{Amb1} \\ KSI_{Amb2} \\ \dots \\ KSI_{AmbN} \end{bmatrix} & 0 \\ 0 & 0 & \begin{bmatrix} KSI_{Soc1} \\ KSI_{Soc2} \\ \dots \\ KSI_{SocN} \end{bmatrix} \end{bmatrix} = \begin{bmatrix} Assess_{Econ} \\ Assess_{Amb} \\ Assess_{Soc} \end{bmatrix}^T$$

Fig. 4. Sustainability Index Fusion

Lotfi Zadeh introduced the Fuzzy Logic in 1960, in order to respond to problems with non-probabilistic uncertainties [9]. Since the beginning, fuzzy logic technology has been widely applied to support decision-makers in the classification of complex problems. Fuzzy Logic is the opposite of certainty and precision. Indeed, this technology is normally used when there isn't quantitative detailed knowledge and uncertainty is significant in the system to be analysed. Moreover, fuzzy logic is presented as an interesting tool to model non-linear systems, which are very common in the real world. With this non-linear system model, it is possible to achieve a higher definition, diminish the modulation error and characterize more complex systems. The supporters of this tool argue that everything that cannot be clearly defined is classified as fuzziness, therefore the adequacy of this approach. The Fuzzy system model is divided into four main stages according to Figure 9.

The fuzzyfication process specifies the system's fuzzy inputs mapped in qualitative outputs.

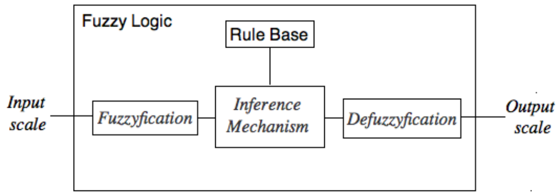

Fig. 5. Fuzzy Logic Schema

Each fuzzy variable is set up by states, which are sets that have a membership function associated. In a simplified way, a membership functions can be seen as a graphical representation of the magnitude of each input's participation. Then, in order to normalize the KSI inputs in the image of the network system, it is essential to have relevant knowledge about the impact of each KSI on the system that will be modulated in order to setup the fuzzy logic control.

Indeed, dependent on the impact of each KSI value oscillation, the system manager can tune the membership function in order to represent this impact factor. For example, as depicted in the graph represented in figure 6, the behaviour produced by the B2 curve is much more reactive than the one produced by the B1 curve. This can be easily observed in a real scenario, in any of the sustainable dimensions. Taking the environmental dimension as example, it is well known that the impact of the CO2 within the environment condition, despite negative, is lesser harmful than methane. Therefore, taking this as knowledge base, the production system manager can tune each of the behaviour curves in order to describe and distinguish the impact caused by a little oscillation in both cases.

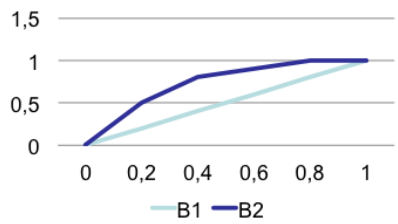

Fig. 6. KSI Impact Behaviour

To compile the knowledge existing about relationship between the different KSI for each sustainable dimension, normally represented by output linguistic values, a rule matrix is used (e.g. "if X is very high, and Y is high, then Z is very Low"). When the rules matrix that model the system and support all the combinations possible between the KSI are defined, it becomes critical to define the contribution of each rule for the fuzzy system, using for example the Mamdani-type. In the following picture (see figure 7) it is possible to visualize the main steps described previously.

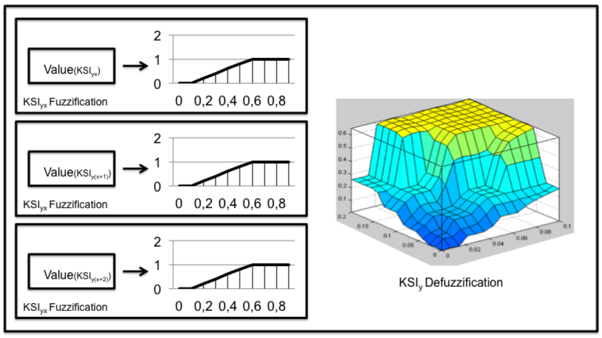

Fig. 7. Overall Framework

In order to get the fuzzy result, it is necessary to translate the variable fuzzy states into real and concrete values (defuzzyfication process). In order to perform this operation it is usually applied the centre of gravity method, also known as centroid. This method consists of calculating the fuzzy set mass centre. At this stage, it is already available the assessment value for each of the sustainability dimensions. However, in order to calculate the overall Sustainability Index, it is necessary to perform a final estimation. The SI value is equal to the multiplication of each of the assessment dimensions, as presented in the equation of the figure 8. Because this formula is based in a multiplication, deficiencies or low indicators values in any dimension are severely multiplied producing an overall more balanced evaluation.

$$SI = Assess_{Econ} * Assess_{Env} * Assess_{Soc}$$

Fig. 8. Sustainability Index Formula

As it is possible to observe from the defuzzyfication, the different plots that compose the SI calculation at final stage are used as if they pose the same importance for the overall network sustainability. However, this only can be true, because during the fuzzification process, the network manager has the chance to define the membership functions and, therefore the corresponding importance and impact for the overall network sustainability.

This type of calculation for SI results in severe values if one or more of the sustainability dimensions are low, emphasizing the need to guarantee the improvement in all three dimensions of sustainability.

CONCLUSIONS

At the core of sustainable development is the need to consider “three dimensions”: social, economical and environmental. No matter the context, the basic idea remains the same, people, habitats and economic systems are inter-related. It is common to ignore this interdependence for short periods of time, but history has shown that before long, mankind is reminded of it by some type of alarm or crisis.

Especially in new type of organizations such as Collaborative Networks, the sustainability issues arises as relevant in performance evaluation and risk assessment for the survival of the network.

In line with this, the current work presents the main concept and vision of the Key Sustainability Indicators as means to evaluate the longer-term implications of current decisions and behaviours in CN. These can be seen as special key performance indicators that should be capable of expressing the behaviour of a network in three described dimensions: Environment, Social and Economical.

In order to compile all the data referent to each of the sustainable perspectives, this paper presents a framework that supports not only the KSI selection, but also the Sustainable Development index calculation. Indeed, with this information, it is possible to introduce a useful measure capable of support decision makers evaluating if the CN is achieving sustainable development. Moreover, this framework is capable of providing a benchmark mechanism, to help managers comparing and assessing different networks in a coherent way.

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RESOURCES SELECTION FOR AGILE/VIRTUAL ENTERPRISES PART II - PROTOTYPE/DEMONSTRATOR TOOL

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Abstract: The process of creation/development of an A/V E is not simple. Due to the large number of potential resources is important to make a selection of those who give more guarantees in terms of success in this cooperation and bring more value to A/V E. There are several projects of A/V E with different approaches to the selection process. The Virtual Enterprise Architecture Reference Model (BM_VEARM) project incorporates a model of resource selection. Considering the aspects of the model the main objective is the development of a tool for pre-selection of resources in MATLAB, and its integration with an algorithm for the final selection. The result is the tool named Selec_E A/V_V2 with the following features: Pre-selection of resources without integration of the Value Analysis (VA), with integration of VA and final selection of resources given to those mentioned cases. This tool will support the development of BM_VEARM selection model and will permit the validation of the importance of VA in the resources pre-selection.

Keywords: agile/virtual enterprises, resources selection, resources pre-selection, value analysis, MATLAB

INTRODUCTION

The main objective is to quantify the performance of the pre-selection with the VA integration, according to the model developed. It is intended to validate that the VA incorporation brings quality and quantity benefits to the overall process of resources selection, particularly in the pre-selection phase. In order to test this assumption, a demonstrator was defined and built. This should support a simulation plan of the pre-selection and consequent final selection with and without the VA integration global model. Certain conditions and restrictions were established in order to identify and quantify the domains of the validation of the model, intended to be as comprehensive as possible.

The main goal of this work is the development of a resources pre-selection tool that will be integrated with the selection model, in order to make the resources selection process quicker and more efficient.

PROBLEM PRESENTATION

The main goal of this work is the creation of a data input tool for the pre-selection of resources to an A/V E which should be capable to integrate within a Branch&Bound algorithm for the final selection of resources [1].

After the analysis on the pre-selection subject, the pseudo-code shown below is created, serving as a guideline for the creation of the code in MATLAB language, which will be integrated with the final selection algorithm.

The problem to be solved is the transposition of the selection of resources model with VA integration to MATLAB code, using the pseudo code developed on Part I of this article.

The main steps of the algorithm model are described below in the form of pseudo code and according to the model conceptual framework and its IDEF0 representation and description [2].

Consider:
PTP$_i$ *= {TP$_1$, TP$_2$, ... TP$_n$} - set of tasks of the processing Task Plan;*
P *– algorithm parameters;*
TP$_i$ *– processing task, i = {1, 2, …, n};*
Rps_1(TP$_i$) *– set of pre-selection requisites of level 1 for task TP$_i$;*
Rps_2(TP$_i$) *- set of pre-selection requisites of level 2 for task TP$_i$;*
Sma *– minimum value*
DS_Rps_1(TP$_i$) *– solution domain for pre-selection requisites of level 1 for task TP$_i$;*
PR$_i$(TP$_i$) *– proposals for each TP$_i$, PRi = {1, 2, …, n)};*
PI *– information search;*
Drp$_{ij}$ (TP$_i$) *= {rp$_{i1}$, rp$_{i2}$, …, rp$_{in}$} - set of candidate resources to pre-selection of the task TP$_i$;*

rp_{ij} *– candidate resource j to pre-selection of the task TP_i;*
F.O. (Rps_1)(TP_i) *– objective function of level 1 requisites associated to the pre-selection systems of task TP_i;*
F.O. (Rps_2)(TP_i) *– objective function of level 1 requisites associated to the pre-selection systems of task TP_i;*
F.S.Q. *– objective function of quality system;*
F.S.S. *– objective function of financial system;*
F.S.S *– objective function of synergies system;*
Pps(rp_{ij}) *– pre-selection parameters of resource j, that candidates to task TP_i*
gf *– flexibility*
Φ *– weighting*
Global F.O. *– global value of resource candidate*

Begin
For PTP:
Define P and continue
%-------- Qualitative Phase ---------------%

For each TP_i do
Define *Rps_1* (TP_i)
Define *Rps_2* (TP_i)

For each *Rps_1* (TP_i)
Define *Sma or DS* and continue

For the *PRi*:
PI and continue
%---------------- Qualitative Phase ------------------%

For the Drp_{ij} (TP_i) execute:
Evaluate *F.O. Rps_1* (TP_i)
If Pps(rp_{ij}) ≠ *Sma dos Rps_1* (TP_i)
or *Se Pps*(rp_{ij}) ≠ *DS_Rps_1*
Then *Sma = Sma + gf*
(redefine *Sma* with *gf)*
Evaluate F.O. *Rps_1* (TP_i)*1*
Pre-Select rp_{ij} and continue

% ---------- End Evaluation level 1 ---------%

For the Drp_{ij} (TP_i) fulfilling F.O. *Rps_1* (TP_i) execute:
Evaluate F.O. *Rps_2* (TP_i)
Φ Rps_2 for each system
Evaluate F.O. *Rps_2* (TP_i) for each system and continue
$F.S.Q.\_rp_{ij} = \sum (\Phi SQi * PQi\_rp_{ij})$
$F.S.F.\_rp_{ij} = \sum (\Phi SFi * PFi\_rp_{ij})$
$F.S.S.\_rp_{ij} = \sum (\Phi SSi * PSi\_rp_{ij})$
Pre-Select rp_{ij} and continue

% --- End Evaluation level 2 per system---%

Determine *Global F.O.* of rp_{ji} to the TP_i and continue
$\sum ((\Phi SQ_i * PQ_{i}\_rp_{ij}) + (\Phi SF_i * PF_{i}\_rp_{ij}) + (\Phi SS_i * PS_{i}\_rp_{ij}))$

% ------- End Evaluation level 2 -------------%

Pre-Select rp_{ij} for the TP_i
End

DEMONSTRATOR TOOL

The language chosen was the MATLAB program because it adjusted to the desired objectives for our demonstrator. MATLAB is a system for scientific calculation that provides a user-friendly environment with an intuitive yet powerful notation which allows the performance of numerical algorithms on arrays with minimal programming. Also, in MATLAB is possible to create and manipulate arrays without prior scaling and manipulation of variables can be performed interactively. Due to its extension and the scope of the work it will not be represented the programming language of the model that transposes the algorithm referred before [3, 4].

MODULES OF THE TOOL

The tool code is divided in modules in order to permit a simpler understanding and a better implementation, giving the program a flexible base to adjust to subsequent developments.

The Base module will be responsible for the initial data inputs and also for the calling of the other modules (pre-selection, selection, and presentation of the results).

In a high level overview, the base module pseudo code can be presented like this:

Asks the input of data
Minimum requirements
Number of Plans
Number of tasks
Weighting values
For each Plan
Calls the pre-selection module
Calls the selection module (without **VA**)
Calls the presentation of results module
Saves the results of the pre-selection and selection modules (without **VA**)

Calls the selection module (considering **VA**)

Calls the presentation of results module

Saves the results of the pre-selection and selection modules (without **VA**)

Rename the storing variables to keep the data of all cycles.

In the same basis of presentation, the pseudo-code of the pre-selection module is the following one:

For each task of the Plan in question

Generates a matrix with random data of the resources

Verification if the generated values are within the limits allowed

1st level evaluation

Weighting the values

Count the number of resources with positive classification in each system of evaluation

2nd level evaluation

Presents results

Stores the intermediate matrices

Generation of the Processing Costs array (**CP**)

After the creation of the pseudo codes presented above, there were created two flowcharts that allow an easier understanding of the steps that the algorithm will take. They are presented in figure 1 and figure 2, for the base module and pre-selection module respectively. For the selection module, that was already created, the flowchart is the presented in figure 3.

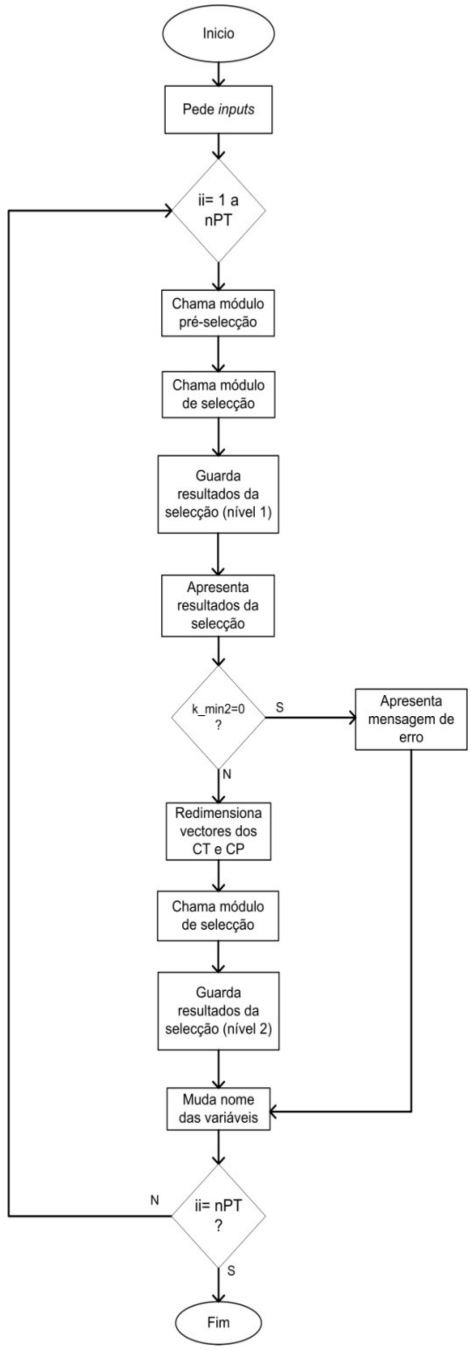

Fig. 1 - Base module flowchart

The selection module will make the generation of transport costs (CT) for the resources that passed the pre-selection and will select the resources based on an algorithm for cost optimization of type Branch and Bound.

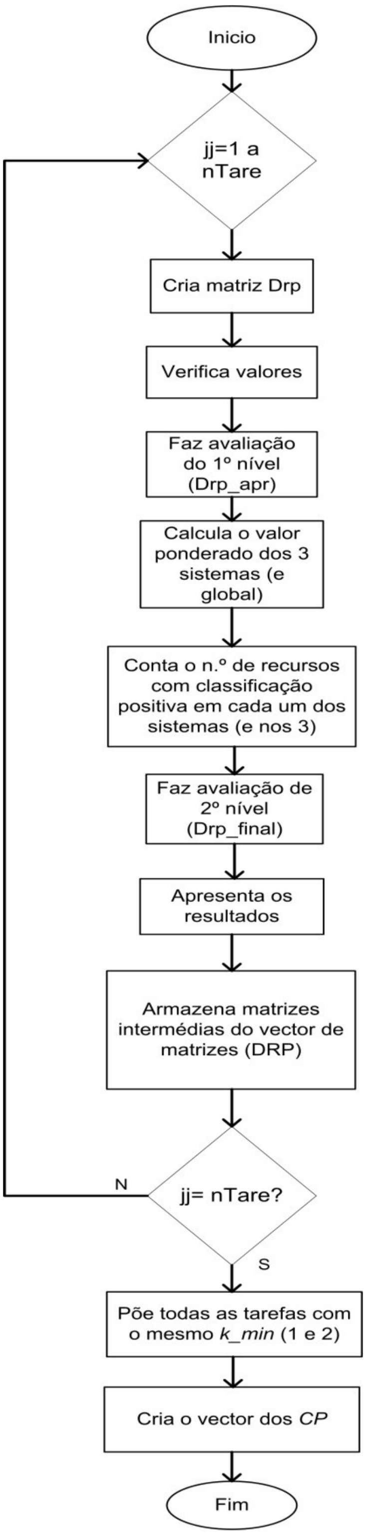

Fig. 2 - Pre-selection flowchart

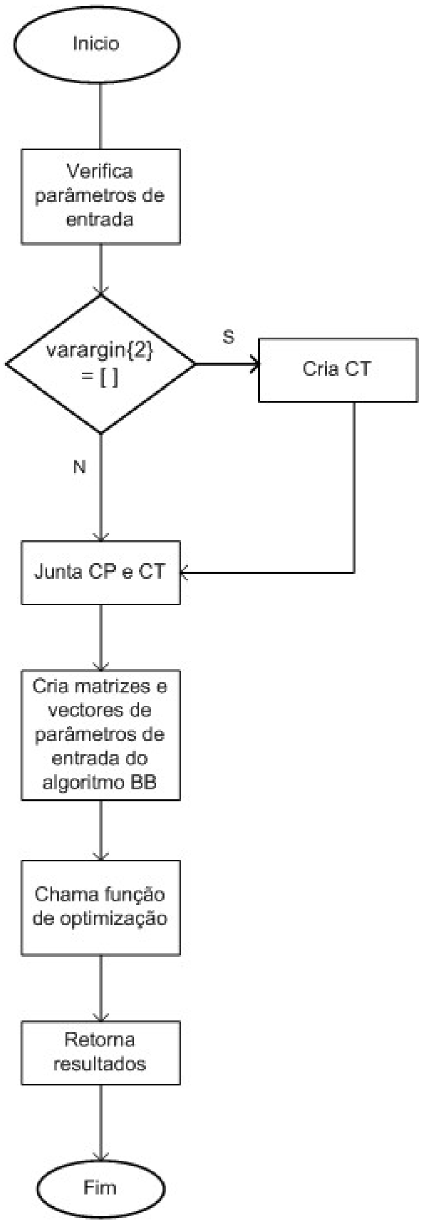

Fig. 3 - Selection flowchart

OUTPUTS OF THE TOOL

The Base module is responsible for the data inputs, calling the other modules, and storing the processed data.

The inputs are the number of Plans, the number of tasks of each Plan and the number of candidate resources for each task. Also on this phase will be inputted the weighting values for each system to be calculated. After this the program enters in self mode, not requiring human intervention.

```
Número de plano de tarefas a analisar: 1

Para o plano de tarefas 1 indique número de tarefas
N.º de tarefas: 4

Plano de tarefas n.º 1
O número de recursos é igual para todas as tarefas? (s/n): s

Introduza o número de recursos candidatos às tarefas: 10

Introduza os valores de ponderação para os 3 sistemas em % (Se todos iguais prima enter):

Introduza os 5 valores de ponderação da qualidade em % (Se todos iguais prima enter):

Introduza os 5 valores de ponderação financeiros em % (Se todos iguais prima enter):

Introduza os 5 valores de ponderação das Sinergias em % (Se todos iguais prima enter):
```

Fig. 4 - Inputs

As it can be seen in figure 1, after the inputs, the Base module will call the pre-selection module. In the pre-selection module, figure 2, the process will be task by task. This module will receive entry parameters (the number of tasks of the Plan being analysed, the number of candidate resources that is equal for all tasks of the Plan, the minimum requirements mentioned above and the weighting ratios).

In the first place, a matrix (table 1), called Drp, will be created using distribution functions since in this phase it's only a matter of simulation in order to prove the importance of the Value Analysis (VA) and to make sure that the program works properly. Afterwards it's expected that the values will be obtained throw surveys to the candidate resources.

The values will be verified to make sure that they are within the defined limits (between zero and ten).

The 1[st] level evaluation of the pre-selection will eliminate the resources that don't achieve the requirements to pass to the next phase. For simulation effects, only those who have the value "1" in all off the 1st level requirements (red box of the table) will pass.

Recurso	Requisitos 1º nível				Classificação nos requisitos do sistema da Qualidade					Classificação nos requisitos do sistema Financeiro					Classificação nos requisitos do sistema das Sinergias					CP
1	1	1	1	1	3,0338	3,9595	5,1060	6,2193	8,2575	5,4201	8,5231	6,9508	8,3482	6,2539	4,6864	3,0372	6,3110	7,6371	5,4148	4,9184
2	1	1	1	1	6,0917	5,8724	7,2227	6,2186	9,6280	6,6240	9,6090	4,5538	7,0531	5,4795	7,2003	7,1879	1,6280	3,3459	3,1180	6,8037
3	1	1	1	1	3,8967	6,7949	4,4962	9,0325	5,9349	9,2720	5,1499	7,1789	5,8744	1,9561	4,0357	7,2250	5,8902	3,7625	4,7472	6,4990
4	1	1	1	0	3,8403	6,3984	2,9579	4,5527	4,8135	6,8027	7,8843	6,6010	5,2539	7,6310	7,5978	6,2404	7,1425	6,8256	4,0261	7,5191
5	1	1	1	1	5,7364	7,1907	8,0937	5,6041	6,6554	5,5234	6,4592	6,8800	4,7663	6,5497	7,2022	6,1846	9,4597	4,7829	4,5259	2,5002
6	0	1	1	1	6,3674	6,5816	6,2259	6,8799	6,2033	10,0000	3,6667	2,2914	3,7186	3,8133	5,1328	5,6631	5,5629	7,0827	6,7785	7,5025
7	0	0	1	1	7,8039	2,3287	6,1335	6,0710	10,0000	5,8616	4,9854	6,4716	6,4916	6,1401	4,7828	3,5548	6,6330	3,3143	3,9356	8,6624
8	1	1	1	1	8,0587	5,3099	8,0256	7,2587	5,5740	4,2686	3,9138	5,4599	5,1237	5,1827	7,9671	5,4046	8,2874	4,9368	7,9451	4,9555
9	1	1	1	1	10,0000	7,9020	5,1360	7,2979	5,2798	7,4118	8,8317	2,7910	8,0577	8,9159	6,0949	9,4925	6,3108	3,5258	1,6130	5,3332
10	1	1	1	1	6,2880	2,7227	4,4798	4,3624	7,0395	5,9717	3,6889	5,9810	4,6204	4,6666	7,7283	6,2268	6,7967	7,7679	6,3605	7,1017

Table 1 - Matrix Drp, with resource's data

Before the 2[nd] level evaluation, the five evaluation criteria of each considered system must be weighted in order to obtain a classification for each system and the global weighting (ratio between the three systems), that can be seen in table 2. In the 2[nd] level evaluation, only those who obtain positive classification (five or more) on the three systems will pass, table 3.

Being

r_{ij}; (j = 1, n), (i = 1, k): candidate resource j for task i

F.S.Q.: Objective Function of Quality System

ΦSQ_i; (i = 1 a 5): Weighting of requirements i of Quality System

$PQ_{i}\_r_{ij}$: parameter of candidate resource j to task i for the requirements Qi.

$$(\Phi SQ1 * PQ1\_rij + \Phi SQ2 * PQ2\_rij + \Phi SQ3 * PQ3\_rij + \Phi SQ4 * PQ4\_rij + \Phi SQ5 * PQ5\_rij) = F.S.Q.\_rij .$$

Doing the substitution by the table 1 values, and having in consideration that the ratios are equal to all the criteria of the system we obtain,

$$(0{,}2 * 3{,}0338 + 0{,}2 * 3{,}9595 + 0{,}2 * 5{,}1060 + 0{,}2 * 6{,}2193 + 0{,}2 * 8{,}2575) = 5{,}3152 .$$

Which proves that the calculus is being well performed.

Table 2 – Matrix Drp_final, with resource's evaluation (1st level and systems weighting)

Recurso	V.S.Q.	V.S.F.	V.S.S.	C.Pond	CP
1	5,3152	7,0992	5,4173	5,9439	4,9184
2	7,0067	6,6639	4,4960	6,0555	6,8037
3	6,0311	5,8862	5,1322	5,6832	6,4990
5	6,6560	6,0357	6,4311	6,3743	2,5002
8	6,8454	4,7897	6,9082	6,1811	4,9555
9	7,1231	7,2016	5,4074	6,5774	5,3332
10	4,9785	4,9857	6,9761	5,6467	7,1017

Table 3 – Matrix Drp_final, with resource's evaluation (1st and 2nd level)

Recurso	V.S.Q.	V.S.F.	V.S.S.	C.Pond	CP
1	5,3152	7,0992	5,4173	5,9439	4,9184
3	6,0311	5,8862	5,1322	5,6832	6,4990
5	6,6560	6,0357	6,4311	6,3743	2,5002
9	7,1231	7,2016	5,4074	6,5774	5,3332

The lines of the matrix will be ordered by the global classification of the resources (5th column)

After that, the presentation of the results of this phase and the storage of all the matrixes (initial, intermediate and final) in a cell array, DRP, figure 5.

```
Para a Tarefa 1

 Referente ao nível 1 do algoritmo (sem avaliação do valor dos recursos)

  Candidataram-se 10 recursos, dos quais foram aprovados 7 no nível 1 do algoritmo de pré-selecção

 Referente ao nível 2 do algoritmo (com avaliação do valor dos recursos)

  6 recursos tiveram nota positiva no S.Q.
  5 recursos tiveram nota positiva no S.F.
  6 recursos tiveram nota positiva no S.S.
  4 recursos tiveram nota positiva nos 3 sistemas

 Recurso   V.S.Q.    V.S.F.    V.S.S.    C.P.
    9      7.1231    7.2016    5.4074    6.5774
    5      6.6560    6.0357    6.4311    6.3743
    1      5.3152    7.0992    5.4173    5.9439
    3      6.0311    5.8862    5.1322    5.6832
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
```

Fig. 5 - Results presentation (task 1)

The program will then redo all this cycle until it analyses all the tasks of the plan. After the analysis of all the tasks, the program will normalise the number of resources that passes on each level. For example, let's consider that a given Plan have 4 tasks. The number of candidate resources is the same for all the tasks. Let's assume that for the 1st task, the number of resources that passes the 1st level is eight. For the 2nd and 3rd tasks, the number of resources approved is eleven and for the 4th is six. In this example, and making the normalization, all the 4 tasks will have the same number of resources approved considering the minimum of all four, which means that the number of resources approved is going to be six.

The same concept is applied to the 2nd level analyses.

```
DRP =

    [10x21 double]    [10x21 double]    [10x21 double]    [10x21 double]
    [ 7x17 double]    [ 6x17 double]    [ 7x17 double]    [ 6x17 double]
    [ 7x6  double]    [ 6x6  double]    [ 7x6  double]    [ 6x6  double]
    [ 6x6  double]    [ 6x6  double]    [ 6x6  double]    [ 6x6  double]
    [ 4x6  double]    [ 3x6  double]    [ 4x6  double]    [ 5x6  double]
    [ 3x6  double]    [ 3x6  double]    [ 3x6  double]    [ 3x6  double]
```

Fig. 6 - Another example of the normalization of the number of resources in both levels (At red, the resources approved at each level and at blue the normalization)

The next step is the creation of the Processing Costs array (CP). To do this, the program will access to the last column of the matrix of each task and copy the values to a new array. This array (CP) will be one of the entry parameters for the selection module.

```
>> PT{4,1}

ans =

    9.0000    7.1231    7.2016    5.4074    6.5774    5.3332
    5.0000    6.6560    6.0357    6.4311    6.3743    2.5002
    8.0000    6.8454    4.7897    6.9082    6.1811    4.9555
    2.0000    7.0067    6.6639    4.4960    6.0555    6.8037
    1.0000    5.3152    7.0992    5.4173    5.9439    4.9184
    3.0000    6.0311    5.8862    5.1322    5.6832    6.4990

>> PT{4,2}

ans =

    4.0000    4.8691    6.4578    7.5724    6.2998    8.1269
    9.0000    6.9982    6.3518    5.3414    6.2305    2.8990
   10.0000    5.4388    6.6651    6.0950    6.0663    6.8022
    5.0000    5.1126    5.6815    5.9534    5.5825    3.2295
    6.0000    7.0753    4.9980    4.6014    5.5583    7.5591
    3.0000    3.9220    6.2440    6.2969    5.4877    2.7454

>> CP

CP =

  Columns 1 through 10

    5.3332    2.5002    4.9555    6.8037    4.9184    6.4990    8.1269    2.8990    6.8022    3.2295

  Columns 11 through 20

    7.5591    2.7454    4.3805    3.8938    6.8184    5.5909    5.3534    7.0817    5.1015    4.7628
```

Fig. 7 - Creation of the Processing Costs array

In the example of figure 7, are presented two tasks. The values surrounded in the 1st matrix by the red line consist in the processing costs of the resources of the 1st task that passed the level 1 evaluation. They are the first ones of the CP array that is being showed in the last part of figure 7, also surrounded by a red line. In a similar way, the values of the 2nd matrix, surrounded by a blue line, represents the processing costs for the 2nd task and are the second ones to be part of the array.

The pre-selection module will return to the base module the cell array with all the matrixes and the CP array.

Back to the base module, the number of resources that passes the 1st level of the pre-selection, *k_min1*, will be checked and will be another of the entry parameters of the selection module, as the CP array and the number of tasks of the Plan in analysis.

The outputs of the selection module (without Value Analysis) will be the array *x1*, which will allows us to identify the selected resources and the related Transportation Costs (CT), the variable *fx1* which will give us the total cost of the system, *exitflag1* to know if it's the optimal solution or not and a structure, *output1*, with different fields as the number of iterations realized to achieve the solution and the time used, among others.

It's inside this module that the CT is created for the first time with the dimensions of (n.º of tasks-1)**k_min1***k_min1*. After that, an array, *f*, will be created, being the binding of the CP and CT arrays.

One of the outputs will be the array *x1*, which has the dimensions of the referred array *f*, being in this case a Boolean type. This means that the array *x1* will be filled only with ones or zeros and the ones means approval (selected resource). Having in consideration the case that is being presented where *k_min1* is six the CP array has a dimension of 24 (ntasks**k_min1*). This means that each "1" found on the firsts 24 positions of *x1* array corresponds to a Processing Cost that is related to a resource that has been selected. The "1" found in the remaining positions are the Transportation Costs between the selected resources. This means that the first "1" found after the first 24 positions is the Transportation Cost between the 1st and the 2nd task, the second is the cost between the 2nd and 3rd task and so on.

Using a function of MATLAB (find) we can easily obtain the positions of *x1* array that where filled with "1". Therefore is created a new array, *locali*, which contains the positions where the "1" are located, figure 8.

```
>> locali'

ans =

     2     8    14    24    32    68   128
```

Fig. 8 - Locali array

In the case of the elements signalised at red, the first (number 2) has a direct correspondence to the resource of the 1st task matrix (column 1, line 4 of cell array DRP, figure 6). In the rest of the elements, (8, 14 and 24) it's necessary to subtract the (number of task minus 1) multiplied by *k_min1*. Using the example, for the second task, we need to subtract 1**k_min1* to the value 8, obtaining the value 2. This value corresponds to the 2nd resource of the 2nd task matrix (column 2, line 4 of cell array DRP). For the 4th number, the selected resource will be the number 6 of the matrix (24 – 3*6 = 6). The positions of the resources at their respective positions can be seen on figure 9.

After the positions of each selected resource being found, the number of the resource, the final classification (global weighting) and CP associated will be stored in the 1st cell of another cell array, *valor*. At each iteration the position of the resource is identified and the data is copied to the 1st cell of the cell array *valor*, figure 10.

```
>> DRP{4, 1}

ans =

    9.0000    7.1231    7.2016    5.4074    6.5774    5.3332
    5.0000    6.6560    6.0357    6.4311    6.3743    2.5002
    8.0000    6.8454    4.7897    6.9082    6.1811    4.9555
    2.0000    7.0067    6.6639    4.4960    6.0555    6.8037
    1.0000    5.3152    7.0992    5.4173    5.9439    4.9184
    3.0000    6.0311    5.8862    5.1322    5.6832    6.4990

>> DRP{4, 2}

ans =

    4.0000    4.8691    6.4578    7.5724    6.2998    8.1269
    9.0000    6.9982    6.3518    5.3414    6.2305    2.8990
   10.0000    5.4388    6.6651    6.0950    6.0663    6.8022
    5.0000    5.1126    5.6815    5.9534    5.5825    3.2295
    6.0000    7.0753    4.9980    4.6014    5.5583    7.5591
    3.0000    3.9220    6.2440    6.2969    5.4877    2.7454

>> DRP{4, 3}

ans =

    7.0000    7.3641    6.5484    6.1106    6.6743    4.3805
   10.0000    6.2799    7.7712    4.5040    6.1851    3.8938
    5.0000    6.4435    5.9543    5.9823    6.1267    6.8184
    6.0000    6.2969    5.7011    6.0554    6.0178    5.5909
    8.0000    6.6797    5.6699    5.2741    5.8746    5.3534
    2.0000    4.6783    5.6014    6.6621    5.6473    7.0817

>> DRP{4, 4}

ans =

    8.0000    6.2636    6.1886    6.7580    6.4034    5.1015
    9.0000    5.9717    6.4221    6.0769    6.1569    4.7628
    5.0000    6.2932    5.9528    5.6323    5.9594    7.1062
   10.0000    6.2918    6.2620    5.2899    5.9479    4.6905
    1.0000    6.2242    5.2225    5.6303    5.6923    6.5391
    6.0000    4.8990    5.0826    4.9355    4.9724    6.0347
```

Fig. 9 - Selected resources

```
>> valor

valor =

    [4x3   double]
    [      23.7622]
    [1x24  double]
    [1x108 double]
    [      27.2808]

>> valor{1}

ans =

     5.0000    6.3743    2.5002
     9.0000    6.2305    2.8990
    10.0000    6.1851    3.8938
     6.0000    4.9724    6.0347
```

Fig. 10 - Valor cell array and matrix of the selected resources

The 2nd cell is the value of the system, which is the sum of the global weighting of each selected resource identified by the green box. The 3rd and 4th cells are the CP and CT arrays respectively and the 5th cell is the total cost of the selected system (CP+CT) given by the selection module output, *fx1*.

The next phase is the presentation of the results of this selection that doesn't contemplate the Value Analysis. The module of the presentation of the results is responsible for showing the analysed information in a more user friendly form.

It will show the number of tasks of the Plan, the number of initial candidate resources, the number of resources that were approved in the 1st level, the selected resource system, the cost of the system and his parcels, the value of the system, the number of resources that were selected, having although negative classification, the information if the solution was optimal, the number of iterations that the program used and the time spend.

```
------------------------------------------------------------------
Resultados da selecção final para o Plano de Tarefas 1

N.º de tarefas: 4
N.º inicial de recursos candidatos: 10
k mínimo do nível 1: 6

Sem análise de valor

    Sistema de recursos: R1,5; R2,9; R3,10; R4,6;

    Custo do sistema: 27.2808
        CP: 15.3277
            CP R1,5= 2.5002;
            CP R2,9= 2.899;
            CP R3,10= 3.8938;
            CP R4,6= 6.0347;

        CT: 11.9531
            CT 1->2= 4.1147
            CT 2->3= 3.8495
            CT 3->4= 3.9889

    Valor do sistema: 23.7622
        Valor R1,5= 6.3743;
        Valor R2,9= 6.2305;
        Valor R3,10= 6.1851;
        Valor R4,6= 4.9724;

Nº de recursos seleccionados com classificação negativa: 1

Foi encontrada a solução óptima

N.º de iterações efectuadas: 807

Tempo da simulação = 0 horas,0 minutos e 13 segundos
```

Fig. 11 - Presentation of the selection (without VA)

After the presentation of the results, and back do the Base module, the number of resources that passes the 2nd level will be checked, *k_min2*. If it's only one Plan being analysed, and the *k_min2* is equal to zero, the program ends here, otherwise it's necessary to resize the CP and CT arrays. In the resize of the CP array, there's no difficulty since the CP is always attached with the respective resource. The procedure is the same as the presented for the first creation of CP array, but this time the matrixes that are going to be accessed are the ones that retain the 2nd level evaluation.

In the case of the CT array, it's a little more complicated. In this array we have all the possible transport combinations between the tasks. As presented in figure 12, only for the first two tasks, we have 36 possible transport combinations.

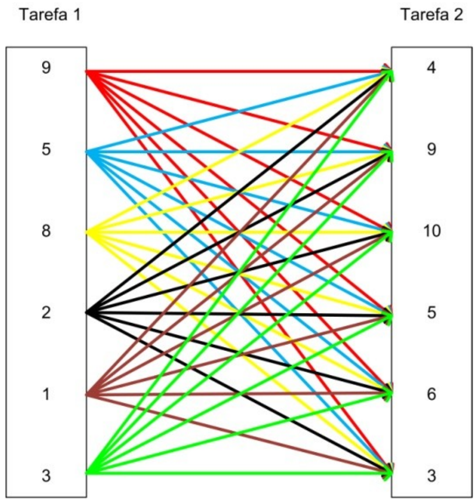

Fig. 12 - Transport combinations between the first 2 tasks

In the 2nd level of the pre-selection some of the resources were eliminated and, therefore, the connections are also eliminated. As the number of resources that passes the 2nd level is 3, the number of possible combinations reduces considerably passing from 36 to only 9 possible connections between 2 tasks, figure 13.

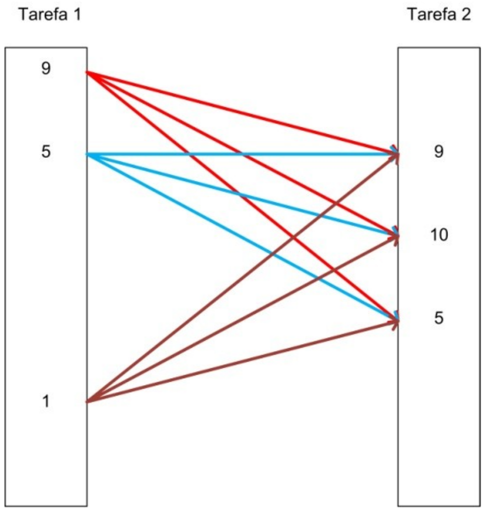

Fig. 13 - Transport combinations between the first 2 tasks after 2nd level evaluation

In the creation of the new CT array, it is necessary a special attention to keep the coherency of the values of the connections. For that, the method found is a restructuration of the values, correspondent to the 2 tasks, into a matrix of dimensions *k_min1* by *k_min1*, or in our example 6 by 6, as in the next figure.

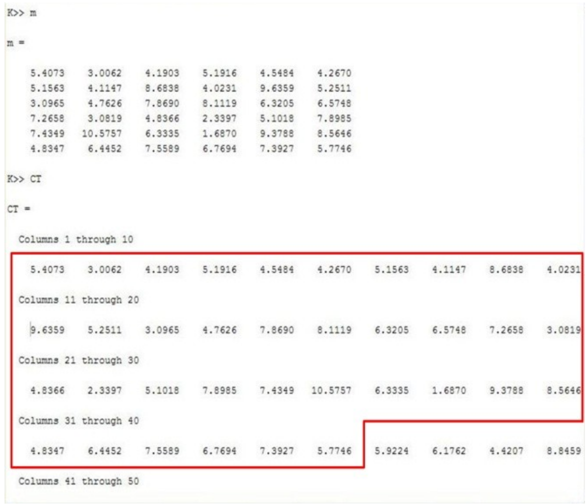

Fig. 14 - Restructuration of the first 36 values in a matrix

This way, and doing a resumed explanation, each line of the matrix corresponds to a resource of the first task (1st line corresponds to the CT of resource 9, 2nd line to resource 5 and so on) and each column corresponds to a resource of the second task (1st column is relative to resource 4, 2nd column to resource 9 and so on). It will be done a comparison between the 2 levels of each task to verify which resources were eliminated of one level to another. After that comparison the positions of the resources that were eliminated will be known and therefore the lines and columns related to them will be filled with zeros. The remaining values are the ones that will be part of the new CT array, CT2.

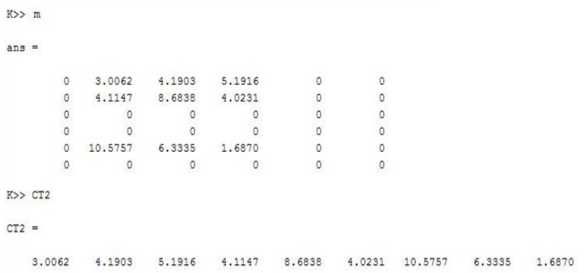

Fig. 15 - Matrix with the remaining values and 1st part of CT2 array

The filling procedure for the rest of the array is similar to the explained above. In the end, the CT2 array will have 27 values while the CP2 array will have 12 values and it's now possible to proceed with the program, calling again the selection module in order to obtain the system with VA.

The steps for this are the same as the explained above for the selection without the VA. The only difference is that the name of the variables is going to be different to avoid conflicts and losing the previous data.

At the end of the presentation of the new results, the total time of simulation is showed as we can see in the figure below.

This tool has already done a set of simulations as a form of support the advantages of a model with a VA in pre-selection phase. Throw these simulations some assumptions were proved, as the higher value of the selected system and the guarantee that all the selected resources have a positive classification in all the considered systems. Another conclusion is that amount of time used by the algorithm is smaller with the integration of the VA in the pre-selection phase.

```
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
N.º inicial de recursos candidatos: 10
k minimo do nível 1: 6
k minimo do nível 2: 3

Com análise de valor

    Sistema de recursos: R1,5; R2,9; R3,7; R4,5;

    Custo do sistema: 30.3663
        CP: 16.8859
            CP R1,5= 2.5002;
            CP R2,9= 2.899;
            CP R3,7= 4.3805;
            CP R4,5= 7.1062;

        CT: 13.4804
            CT 1->2= 4.1903
            CT 2->3= 4.2901
            CT 3->4= 4.9999

    Valor do sistema: 25.2385
        Valor R1,5= 6.3743;
        Valor R2,9= 6.2305;
        Valor R3,7= 6.6743;
        Valor R4,5= 5.9594;

Foi encontrada a solução óptima

N.º de iterações efectuadas: 183

Tempo da simulação = 0 horas,0 minutos e 1 segundos
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Tempo total da simulação = 0 horas,0 minutos e 14 segundos
```

Figure 16 - Presentation of the selection (without VA)

CONCLUSIONS

Based on BM_VEARM model, the selection process consists in two phases, the pre-selection and the selection of resources. The main goal of this work was the development of a pre-selection tool and its integration with a selection module. For that, was necessary an overall comprehension of the pre-selection process for distributed enterprises, develop the pre-selection pseudo code, implement the algorithm in MATLAB, and after the integration with the selection module, the simulation and validation of the tool

Despite the existence of several programs that could be used to develop this tool, the chosen one was MATLAB, due to the mentioned characteristics and due to the fact that the selection module had been already developed using this language making the integration process easier.

The tool was validated having already realized a simulation plan in order to validate the pre-selection model with VA integration.

The optimization of the code can be seen as future development, since that in the beginning of the development of the tool, the knowledge of the language used was low. The creation of a graphic interface, even more user-friendly, the possibility of choosing more than one selection algorithm (besides Branch&Bound) and the importation and exportation of data from/to Excel sheets can also be seen as future development.

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IN-HOUSE OUTSOURCING OF PACKAGING ACTIVITIES

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Abstract: Outsourcing has grown in importance not only as the result of economic and competitive pressure but also because organizations have become more comfortable with the benefits of outsourcing. The increasing number of outsourcers and the degree of expertise acquired, contributed to an increase of the usage, services and approaches to outsourcing. In-house outsourcing is an approach that combines physical location and process execution within the boundaries of the outsourcing organization, that potentiates benefits and diminish risks usually identified to the general outsourcing approach. This paper presents a case study of a packaging process outsourced by a logistic service provider and concludes on the results of the initiative.

Keywords: management, outsourcing.

INTRODUCTION

In today's ever increasing global and competitive market the structure of labour intensive industries is changing. Organizations face higher demands in order to gain a competitive edge. Some focus on reducing operational costs, others on streamlining operations or being responsive to customer needs and changing market conditions or a combination of some or all of these different aspects.

As a management tool outsourcing has been practiced for a very long time, but only recently its use by companies has become more common. The number and the geographical distribution of service providers has grown as well as the diversity of services provided.

This rapid growth created some confusion in the definition of outsourcing. A clarification of the definition was sought by Guilley and Rasheed [3] who consider outsourcing as a highly strategic decision of the purchase from a third party, of goods or services previously performed internally, or that could be performed internally by the existing of expertise or capital capacity. This definition limits the spectrum of types of services that can be serviced outside of an organization that can be considered outsourcing.

When evaluating an outsourcing initiative, there are a number of benefits and risks that need to be taken into account. The benefits and risks can be of strategic, economical or operational nature, and describe the achievement of the project objectives [5]. Independent of the nature of the drivers behind an outsourcing decision, there is always an impact on the definition of the company's boundaries [8]. There are several outsourcing models and categories that allow different ways to define the company's boundaries.

TYPES OF OUTSOURCING

Outsourcing comes in several shapes and forms. The way outsourcing is done can be classified according to criteria such as location, level, sector, type of relation, or span.

When selected by location outsourcing can be classified as on-site or off-site. On-site outsourcing involves the work being done within the physical premises of the client company while in off-site outsourcing the work is done in the outsourcer facilities. Off-site outsourcing can be further divided into onshore, near-shore and offshore, a criteria that is based on the country border of the client company [10].

Outsourcing initiatives can also be classified according to the different levels at which they occur: individual, functional and process level. The individual outsourcing is the simplest form since it involves the outsourcing of specific positions of the organization. The functional outsourcing typically develops through the traditional functional structure of organizations. It becomes easier to outsource through the company's existing organizational structure, both for ease in describing the activities, the inputs and outputs, and identifying their costs. The process outsourcing involves hiring a service provider for the management of an entire business process, not just isolated activities or functions. Greaver [4] e Power [4][10]

Outsourcing can also be classified according to the number of vendors: single-vender and multiple-vendor. Multiple vendor outsourcing is a specific outsourcing arrangement where there is one outsourcing project but multiple services suppliers [7].

The outsourcing degree of external supply use can be classified in total outsourcing or selective outsourcing. Selective outsourcing means that 20-80% of services are transferred. Total outsourcing means that the proportion of outsourced services is over 80% [7][10].

The interactions between operations can also be a sorting parameter. Perrow [9] distinguished between sequential operations and interdependent operations. The "format" of sequential outsourcing arises when a sequential series of transactions precedes in an independent way the activities of the outsourcing company, which is acting as a value incorporator. The outsourcing format with interdependent operations assumes that there are mechanisms of interaction and feedback between the outsourcing company and the outsourcers. The outsourcing company defines a production stage and "delivers it" to another company, controlling only the inputs and outputs of this production stage.

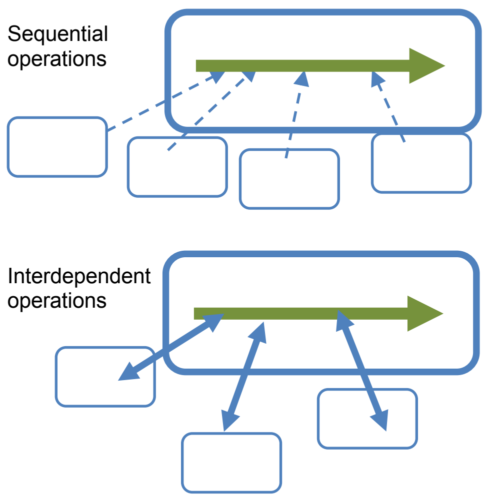

Fig. 1. Sequential vs. interdependent operations

Another parameter of distinction is the systemic complexity of transactions, where a low complexity system allows for various levels of separation between the activities of the outsourcing company and the activities undertaken by companies that provide outsourcing services. Conversely, the more complex the operations become, the less separation between activities is possible.

IN-HOUSE OUTSOURCING

It is common to accept that outsourcing arrangements can be made anywhere. The trend of modular production as in the Volkswagen factory in Resende, Rio de Janeiro [11] (in which outsourcer companies provide modular products which are incorporated into the production flow of Volkswagen) tends to shift the outsourced production to the proximity of the outsourcing company or even to its interior.

This aspect of outsourcing is related to the deployment location of the outsourcer and, as it progresses to a modular production, the physical location of the company providing the outsourcing acquires greater importance.

Within this approach, the in-house outsourcing appears as a combination of on-site and interdependent outsourcing [2]

Bonazzi and Antonelli establish the definition of in-house outsourcing as: *".. the outsourcing of selected phases of the general production process that are sealed both physically and sequentially within the borders and boundaries of the outsourcing firm."* [2].

The impact of the concept of in-house outsourcing extends to areas such as production flow, organization of work, job content and problems related to everyday interactions. The in-house outsourcing concept is based on three main factors:

- Outsourcing in proximity (close to customer premises) or on-site, at client and using open re-contracting;
- The outsourcing company, besides being a customer, is a supplier of intermediate inputs;
- The outsourcing company receives the results of the specialized services that were delivered by the outsourcer.

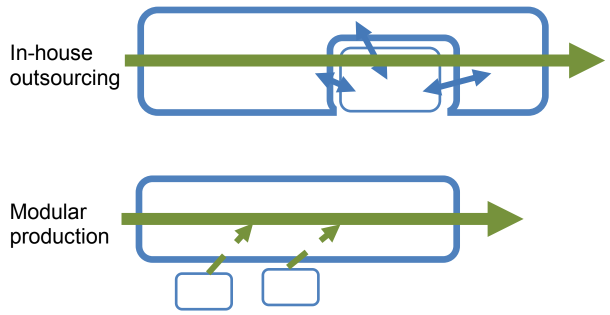

Fig. 2. Modular production vs. In-house outsourcing

In a in-house outsourcing initiative it is common, in an earlier stage, the creation of a business unit, which is "isolated" from other production phases being assigned values (debits and credits) for transactions with the "outside". When the business unit reaches functional maturity and trade independence, outsourcing can be achieved.

Another feature necessary to implement in-house outsourcing goes through the coordination of activities between the outsourcer and the outsourcing company.

Bonazzi and Antonelli assume there are four types of in-house outsourcing, related with the combination of the complexity type and the nature of interactions between operations [2].

The basis for the characterization of all the in-house outsourcing types is the market. When the outsourcing is a combination of sequential operations and low complexity, the market assumes, by itself, the predominant role (this is the most simple type of in-house outsourcing). If the complexity of the outsourcing is low, but the operations are interdependent, a need for information exchange between shop floors emerges as mandatory.

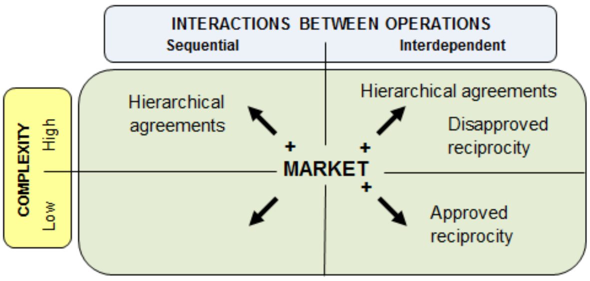

Fig. 3. Four types of in-house outsourcing. (Adapted from Bonazzi and Antonelli [2])

On the other hand, and if the operations are sequential and a greater level of complexity is introduced (like a redefinition of the logistics system), a need for hierarchical agreements between the companies emerges as the way for the outsourcing to succeed.

The most complex type of in-house outsourcing is when interdependent operations and high complexity coexist. That coexistence leads to the need to establish hierarchical agreements between the companies and, in some situations, enabling the companies to act outside those agreements (in order to obtain mutual benefit).

In situations of sequential outsourcing, the coordination of activities undertakes a predominantly bureaucratic aspect of analysis of indicators, while in interdependent forms of outsourcing, there is predominance of a large element of trust and collaboration between companies.

A consequence of the need for coordination of activities is an adaptation (by the outsourcing company) of new forms of production management, which pass through one paradigm shift of orders for production in a single system, to a new system, that constitutes the coordination between inputs / outputs between companies.

This form of coordination also means that the management of contracts with the outsourcer, takes the form of open contracts, to allow for production flexibility and, at the same time allowing to establish in an iterative way, rules that clarify the responsibilities of the parties.

METHODOLOGY

Literature is rich in analysis of benefits and risks [6] but lacks in identifying specific benefits and risks for in-house outsourcing initiatives.

To develop an understanding of the benefits of in-house outsourcing, the context of the outsourcing decision must be taken into account. A case study seemed appropriate since there is a growing number of studies in the field of outsourcing that result from empirical observation and case studies [1].

For the present study one case was selected. The company chosen is a logistics service provider, a mature organization with previous experience in outsourcing activities and positioned among the leaders of its activity sector. The activities to be outsourced in-house were value added activities.

Interviews were made to managers both of the outsourcing and outsourcer companies, documentation concerning the project was consulted and direct observation of work execution at the shop floor was conducted.

IN-HOUSE OUTSOURCING CASE STUDY

The case presented is in the FMCG (Fast moving consumer gods) food distribution sector. The products distributed are fresh dairy products, which are extremely sensitive to health and safety issues.

The supply chain plays an important role in the consumer confidence. There are increasing food security issues regarding the supply chain to ensure that dairy products are kept fresh from the factories to the supermarket shelves. Storage temperature is the most important factor in maintaining the quality of fresh dairy products. For the outsourcing company products, the ideal storage temperature range is from 0° to 4°C. The traceability of the temperatures along the entire cold supply chain is a key factor in ensuring product quality.

There are locations along the cold supply chain, were a breach in the maintenance of the temperature range that preserves the integrity of the product can take place. A special attention must be given to transportation and warehousing activities.

The supply chain also plays an important role in ensuring the achievement of high productivity. Since fresh dairies are perishable products, the tight expiration dates are of particular importance, and determine the execution times of the logistic operation and contribute to the overall productivity performance. Every link in the cold supply chain must minimize spoilage and waste, saving time and costs.

There is heavy competition in the fresh dairy products market. Advertising and sales promotions initiatives play an important role on the fresh dairy industry with a high impact on the volumes and value added activities of the cold supply chain.

The retail sector is increasingly demanding that products are delivered in shelf-ready format as a way to improve store operational efficiency. The shelf-ready formats aren't the same for every retailer and production unit's aren´t ready to respond to variety of formats. This creates a need for re-packaging activities that are postponed in the supply chain.

Value added services such as shelf-ready re-packing, labelling and promotional re-packing play an important role in the supply chain. These services must be integrated within the supply chain to ensure a cost-effective result.

The outsourcing company is a logistics service provider that is specialized in temperature controlled logistics services. It provides a selection of services that range from transport, distribution, storage, to value added services. It has an experience of more than 10 years in the industry.

The value added services provided were re-labelling, shelf-ready re-packaging and promotional re-packaging and re-palletisation. The volumes of these services have strong fluctuations and are difficult to foresee, since they are very dependent on marketing initiatives. The value added services are labour intensive, which require a highly flexible workforce in order to reply to volume fluctuations.

The logistics service provider had a dedicated operation for a dairy products client. The dedicated operation included the transport from manufacturing plants to warehouse, warehousing and transport to distributors.

The client also requested value added services. Having the services done in the same facilities of the warehousing operation had advantages in terms of diminishing the risk of breach of product integrity, since the transport of the product from the warehouse to a contract packaging companies, and the return of the product to the warehouse for further distribution wouldn't take place. Despite the existence of this competitive advantage, the logistic service provider had to compete with contract packaging companies for the value added services.

The request of value added services from the client had grown strongly in the previous years. It ceased to have a residual relevance to become an important part of the supply chain. As a result of this growth the logistics service provider found that the value adding packaging processes lead to a number of quality and productivity problems in both warehousing and value added services.

The origin of these problems was related to the fluctuation of the workforce. For each increase in the volume of packaging services a high number of skilled workers needed to be quickly incorporated to respond adequately to production needs. The solution was hiring a temporary workforce and assign the warehouse supervisor staff the additional coordination and management tasks of the new workforce. During these periods there was a decrease in productivity and service levels.

The client, aware of the logistic service provider's problem, increased the use of contract packaging companies, so that the warehousing operations service levels and productivity were not affected. This situation wasn´t the ideal for the client since it resulted in the increase of transport and operation costs, increased risk for the integrity of the product and productivity reduction for value added services.

Faced with the client's decisions, and having identified the main causes of the problem, the logistic service provider decided that the value added services would be the target for outsourcing. Trying to improve the performance of the value added services internally would pass through the creation of a new supervising structure. Since this solution would need the incorporation of permanent staff, and the company policy didn't allow an increase of the workforce, it was discarded.

The expectation was that through outsourcing the productivity and quality issues would not be influenced by the volume variation and, as consequence, the market share lost to contract packaging companies would be recovered.

An operational assessment of the process to outsource was conducted. Two options were considered. The first was to outsource to a contract packaging company with facilities nearby the warehouse. The second was to adopt an in-house outsourcing solution operating within the warehouse premises.

The first option had the main advantage of freeing warehouse space, but has the disadvantage of adding transport and warehouse operations that increased cost and risk of integrity of the product. Since the logistic service provider already competed with other contract packaging company for the packaging services, the expected financial benefit from this solution was limited. The second option had the advantage of not adding transport and warehouse operations cost but didn't free warehouse space and would require a strong integration with the warehousing activities.

The selected outsourcing strategy was to outsource using an in-house outsourcing model. This work permitted the elaboration of the Request for proposal (RFP). The RFP responses were evaluated and one outsourcer was selected.

The outsourcer selected is specialized on in-house outsourcing of production and logistics labour intensive processes. They provide services in the automobile, retail, telecommunications, and food sectors.

A section of the warehouse was delimitated to be used by the outsourcer, and interface areas for input and output of material were defined. The outsourcing process didn't involved transference of workers and the existing machinery used on the packaging services was transferred to the outsourcer. A new workforce and a management structure were placed on site.

At an operational level the communication channels were established between both parties as well as the procedures.

The transition phase of the work to the outsourcer was done smoothly. During a period of approximately one month, all the work was relinquished to the outsourcer.

After the work transition took place there were some problems related with the coordination of work at the shop floor level, but they were overcome through coordinated management efforts.

Results

Through the use of the in-house outsourcing solution the logistic service provider was able to focus on the warehousing operations and recover the decrease of productivity and quality levels.

With this solution there was no need for the increase of internal staff by the logistic service provider. The outsourcer was the one that managed the workforce variation, which in some situations meant having to increase 250% the number of workers in a single day.

In the packaging services there was also increase of productivity and quality service levels. The execution time of the value added activities was improved by an average of 20% and the quality service levels were well over 99%.

The RFP response time for new promotional services diminished from 72h to 24h. This competitive advantage was achieved through the development of a new process flow.

These improvements contributed to an overall productivity gain of the supply chain.

CONCLUSIONS

In this particular case the logistic service provider had to find a solution that allowed him to access the benefits of outsourcing without using an offsite outsourcing solution since the offsite outsourcer is his main competitor.

Based on the results obtained from this case study it is possible to observe that the outsourcing company had two benefits that could only be achieved through in-house outsourcing:

- Improvement of performance due to the integration of the warehousing services with the value added services;
- Maintenance of the competitive advantage factor in relation to contract packaging companies.

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URBAN TRANSPORT OF THE FUTURE

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Abstract: The development of the society lead to a permanent change on their citizen mobility needs. The offered solutions have not yet been properly harmonized in most developed countries and in the last years, the mobility conditions have become worse. In fact, the transport networks, the infrastructures and, most important, the habits acquired by the citizens are not adapted to the new demands of the society, revealing a misalignment, that is not favourable to efficient performance of the transportation networks.

Keywords: Transport networks, Transportation Systems, Mobility, Vehicle of the future

1. INTRODUCTION

The progress and development determine the whole planning process in metropolitan areas, especially in urban centres. The complexity of this issue affects the most diverse areas such as economics, public health, environment, safety and social aspects. This article aims to give a perspective on the current transportation systems, highlighting some of the most important factors to be considered in future development of sustainable transport systems.

2. THE EVOLUTION OF DEMOGRAPHY AND THE MOBILITY NEEDS

According to [1], the centralization of the main economic activities in urban centres was a direct consequence of the development of large cities in recent decades. This made that the geographic areas of the cities were expanding around it, i.e., promoting the displacement of the population to surrounding areas as a result of high cost and limited living space in the urban centres.

In the past, cars were seen as luxury goods. Nowadays, they can be founded everywhere and are accessible to different social classes, playing a crucial role in the current context of mobility. This fact is critical in changing attitudes, particularly because people have developed behaviours that do not dismiss their daily usage, wanting autonomy and freedom that were not possible in the past. Conception of comfort, freedom, autonomy, speed, convenience and even status obligate to the possession of a vehicle.

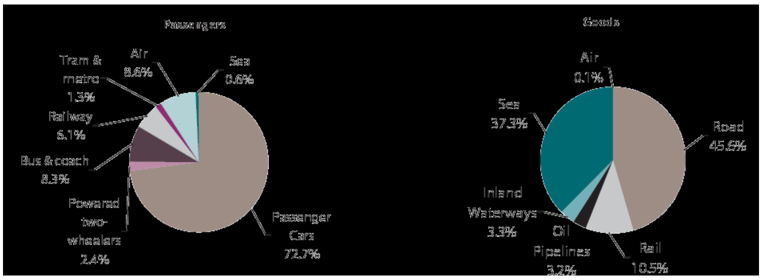
The huge extent use of cars has turned worse the mobility of the passengers, particularly in urban centres, were traffic capacities are nowadays oversized. Besides this, there has been an increasing pressure on environmental issues, which allows predicting that this topic is of major importance in future mobility policies.

According to [2], the urban population is expected to reach to 390.8 million citizens in the EU-27 in 2030, i.e. 79.8% of the total population of EU-27, as a result of the populations trends to migration from rural areas to the cities. This growth in population concentration in urban areas will require new systems and transport policies more efficient than the existing ones.

3. MOBILITY CHARACTERISTICS OF THE EUROPEAN CITIZENS

The mobility of passengers in the 27 countries of the EU region over the last two decades had an average annual growth of, approximately, 1.6% in the overall transport modes [3]. Air transport has the highest average annual growth rate (4.6%), perhaps due to the low cost flights promoted by some airlines companies. Road transport increased by about 2%, mainly influenced by the growth of the motorcycles transport and passenger cars. The public transport by buses had a very mild evolution, roughly keeping the same statistics as in 1995. The transport by tram and metro grew about 1.5% per year, while rail transportation increased about 1% annually. Finally, the shipping had an annual reduction of around 1%.

In Figure 1 we can observe the modal transport distributions in 2006, both for the passengers transport (a) as for the goods transport (b).



(a) (b)

Figure 1 Modal split of passenger transport (a) [% / passenger x km] and goods (b) [% / ton x km] in the EU-27 countries in 2006 [3].

It is important to underline that the passenger transportation has been made mainly by cars, with about 72.7% of total passenger transportation. Also, more than 80% of passenger transportation has been made by road transport in passenger cars, two-wheel motorcycles or buses.

An important factor that influences the mobility is the goods transport. For example, in 2006, about 46% of total freight was carried by road transport, which constitutes a significant occupation of road infrastructures with an important impact on road traffic conditions.

Figure 2 compiles the average distances travelled per inhabitant in 2006 in the EU-27 by different transport modes.

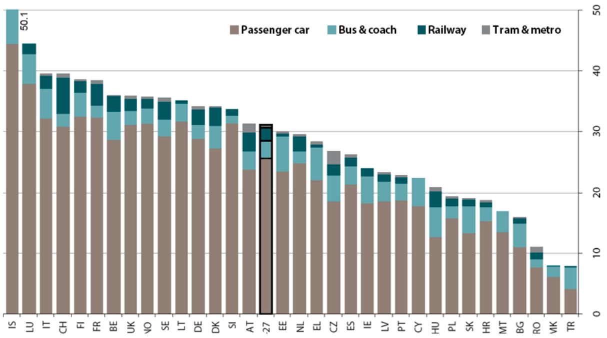


Figure 2 Average distance travelled daily per inhabitant in different modes of land transport in European countries in 2006 (km) [3].

As can be seen, a wide dispersion in the statistics is found but average values of the daily distance travelled by passengers in the EU of 27 countries was about 25 km on passenger cars, about 2.5 km on buses and coaches, about 2.5 kilometres on trains and less than 1 km on metro.

According to [4], about 40% of the journey duration is for leisure purposes, followed by trips to work and to shopping activities. In terms of travelled distance, the trips for leisure purposes are the longest, representing, on average, 40% of the total travelled distance. The shorter trips are used for working, business, shopping and educational purposes.

Figure 3 shows the evolution of the occupancy rates in different types of transport, between 1980 and 2004.

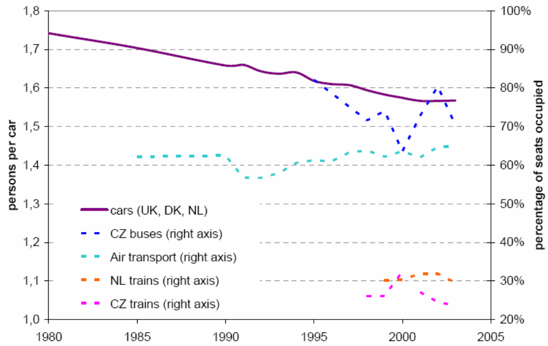


Figure 3 Evolution of the occupancy rates for passenger transport [5].

For the European countries studied, it can be seen that the average number of passenger in cars is less than two and has being declining over the past 25 years. This tendency can be applied to other countries, like Portugal, where the use of private transport, particularly automobiles, has deeply increased over the last years. This is an important characteristic that should be considered in the study of new solutions to improve the efficiency of the transport systems.

4. ECONOMIC, ENVIRONMENTAL AND SOCIAL IMPACT

Energy consumption in the transport sector has been increasing, between 1990 and 2006, at an average annual rate of 1.8%, while energy consumption in industry was reducing. In 1990, the final energy consumption in the transport sector was 26.3% of total final energy consumption in the EU-27. This value has been increasing, reaching 370.4 million of 'tonne of oil equivalent' (TOE) in 2006, i.e., 31.5%, of which 81.9% was consumed in road transport (Figure 4).

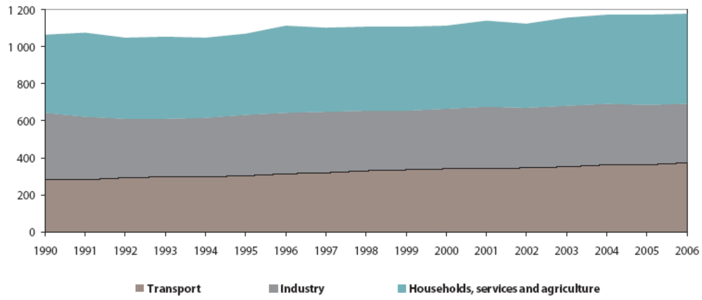
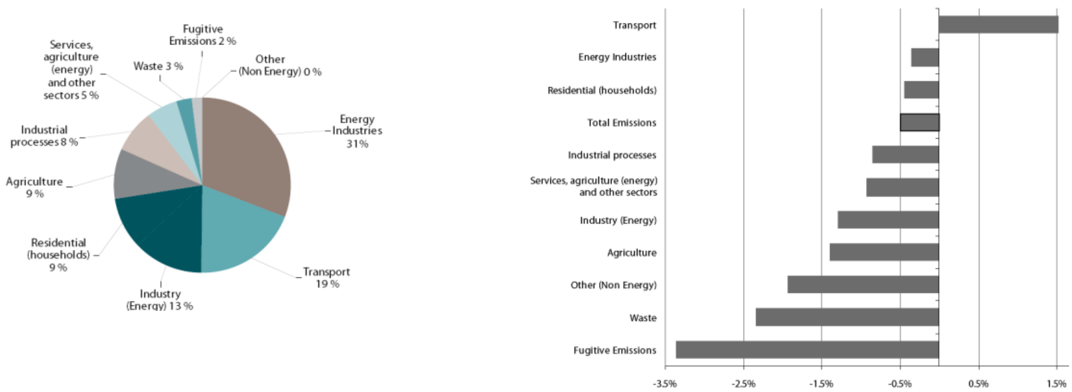


Figure 4 Final energy consumption in transport, industry, housing, services and agriculture, in the EU-27 countries, between 1990 and 2006 (millions TOE) [3]

The growth of vehicle fleets for passengers and goods and a strong increase in the air transport services were the main responsible for the increase of energy consumption in the transport sector, of which, 75% corresponds to road transport, and, the remaining 25%, to air transport.

In 1950 there were about 70 million road vehicles, for a world population of 2.4 billion. In 2000, the number of vehicles has increased to 700 million, while world population rose to 6 billion. This means a ten times increase in vehicles to an increase of two and half times in population. According to [6], it is estimated that the number of vehicles in 2025 will reach 1.4 billion, i.e., the double than in 2000. This significant increase in the number of vehicles will require a significant increase in energy consumption and also in gas emissions that will have a negative influence on the mobility, particularly in cities.

According to the graph in Figure 5(a), the transport sector had the second highest contribution for the total Greenhouse Gases emissions. This sector was the only one where there was no reduction in emissions between 1990 and 2006, as can be seen in Figure 5(b), exhibiting the average growth rate of emissions by sector.



(a) (b)

Figure 5 Greenhouse Gas emissions rates in different sectors in the EU-27 [3].

In 2006, road transport was accounted for 93.1% of greenhouse gases emissions of the transport sector, representing approximately 19.0% of the total greenhouse gases emissions in the EU-27. In 1990, that value was only 13% [3].

5. DEVELOPMENT OF EFFICIENT TRANSPORT SYSTEMS

Sustainable mobility is the ability to meet the needs for travelling, access and communication, without sacrificing, today or in the future, other essential human or ecological values [7].

In recent years, individual mobility has increased proportionately to the people living standards. This behaviour is common in modern societies, and tends to deteriorate the environmental conditions, road safety issues and increase the energy consumption. If this trend is not reversed, the world sustainability will be in question. It will be important to make deep changes, reducing the pressure on the energy consumption and environmental conditions, particularly in cities [8].

The efficiency of a vehicle in terms of emissions and fuel consumption depends on several different parameters. These parameters should be combined, establishing a favourable balance during the vehicle life cycle time. Figure 6 illustrates the main parameters and their influence in reducing energy consumption in passenger cars

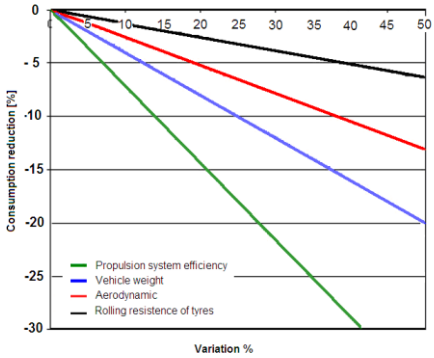


Figure 6 Parameters and their influence on the consumption of passenger cars [adapted from 9].

According to Toyota®, different propulsion technologies have been already developed. Some of the most promising ones have substantial margin for development, and will be probably, valid alternatives for the future (Figure 7).

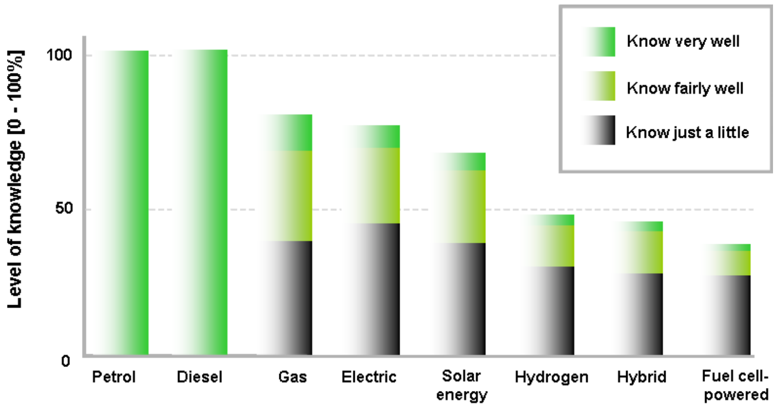


Figure 7 Level of knowledge of the different technologies used in propulsion systems.

According to Figure 7, one can see that there are several alternative propulsion systems to the internal combustion engines. This means that, in future, there should be not one technology but several alternative technologies to be used, according to their specific advantages.

As Figure 8 shows, the weight of vehicles is one of the most important factors with influence on vehicle consumption and CO_2 emissions.

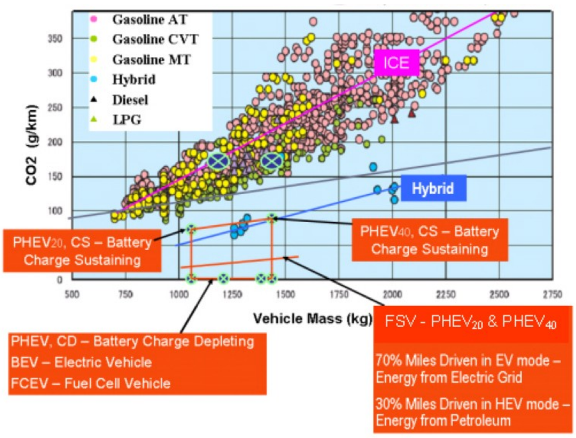


Figure 8 Relationship between weight and CO_2 emissions for vehicles with different propulsion technologies [10].

The development of new lighter materials is one of the areas which can contribute significantly to the reduction of vehicle weight and consequently to efficiency. Nowadays, traditional materials (especially steel) have advantages over others also used in the production of automobiles. However, considering the life cycle of a car, those advantages tend to be less evident, particularly if substantially lighter materials, such as reinforced plastics and composites, are considered. According to the results of the European project TECABS (*Technology for Carbon fibre reinforced modular Automotive Body Structures*) [11], it is possible to reduce the body weight of a city vehicle by about 50%, maintaining the same stiffness characteristics, if composite materials are used.

Aerodynamic optimization can be obtained by efficient vehicle design and can also contribute to the reduction of combustible consumption.

An increase in transport efficiency can be obtained using appropriate communication systems. Automotive industry has been investing in the development of smart urban mobility and multi-modal transportation solutions. As an example, the ITS system (Intelligent Transport Systems) based on communication between vehicles and vehicles and infrastructure can optimize the traffic flow, making easier the access to the cities, reducing energy consumption and emissions. With this kind of systems, it is possible to reduce the consumption and emissions, by increasing the traffic average speed (Figure 9). Moreover, those solutions allow reducing the number of road accidents [6].

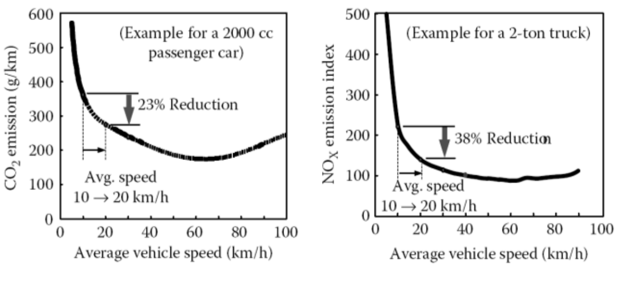


Figure 9 Levels of vehicle emissions in accordance with their average speed [6].

6. TRENDS IN THE AUTOMOTIVE MARKET

According to [12], there will be a growth in the automobile market, particularly in the sectors of small and medium cars. It is important to notice the significant growth of a new segment, the Ultra Low Cost Car (ULCC), which will represent about 15% of the car sales by 2020.

Car manufacturers are nowadays aware of the need to offer new solutions that simultaneously can meet the following requirements: low emissions and small sizes. Recently, some specific solutions for mobility in the cities were developed, as the MPV model T 27 project exhibited in Figure 10(a) shows. This model measures about 2.5 meters long and 1.3 m wide, and weighs only 600 kg. This vehicle uses advanced light materials and derives from a common platform of other model of the manufacturer. In Figure 10(b) one can observe the parking area for this type of vehicle compared to the parking area of a conventional one.

(a)

(b)

Figure 10 Ultra compact City car MPV T27 [13].

7. CONCLUSIONS

The demand by the citizens for more comfortably transport solutions has contributing to the increase of individual transport with low occupancy rates, reducing transport efficiency, which has impact on the energy consumption, vehicle emissions and traffic conditions. Therefore, it is essential to change attitudes, allowing a more rational use of transports. The mobility challenge is to create a harmonized and efficient system, combining all modes of transportation in the most convenient way, ensuring its sustainability.

The individual transportation should be optimized because it has a very significant weight in urban mobility, and, therefore, the use of infrastructures should be optimized with some criteria based on the transport efficiency. It is also important to create specific areas for loading and unloading of goods, bus stops and intermodal terminals for passenger and goods.

According to the targets proposed for the reduction of greenhouse gases emissions, vehicle manufacturers must develop more economic and ecologic vehicles, using new technologies for the propulsion systems, lightweight materials and new vehicle concepts.

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THE ENERGY PERFROMANCE CERTIFICATION OF BUILDINGS AS A NEW SUSTAINABLE AND PROFITABLE BUSINESS

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Abstract: The International Energy Agency (IEA) has identified the building sector as the one of the most cost-effective sectors for reducing energy consumptions. Energy performance is a key policy instrument that can help the governments on reducing energy consumption in their countries and develop the business activity in the energy sector. The building's certification process is quite well implemented among the European Member States. In its early stage, Portugal was ahead of the energy performance certification of buildings with new laws and regulations, i.e., the national implementation of Energy Performance of Building Directive (EPBD). After five years, new business opportunities are on the edge, as it has many threats resulting from cannibalizing of the own business partners and raising unrealistic expectations. This work attempts to explain and to analyse the potential of economical sustainability, from a direct and indirect point of view, that can be obtained from the energy performance certification business. In Portugal, the success and the economic sustainability of the companies are directly linked to the policy will and national authorities' surveillance on the effectiveness of the certification process on the real field.

Keywords: Energy Performance; Energy Certification; Buildings; Business Sustainability

INTRODUCTION

Nowadays Portugal, as well as the other countries around the world, face the same challenge: sustainable development. This issue is the foundation of all modern organized society and is direct related to Energy, Economy, Politics, Social features, but it is mainly linked to the Environmental concerns.

The sustainability is directly linked to the social-economic aspects of any developing country in the world. For a better perception of this relationship it is important to know what the sustainability itself is indeed. In 1987 [1], the sustainability was defined as something related with three generic basic aspects: economic growth, environment and development. The first studies about this subject were made in 1988 [2], and were presented as something related with economic issues and environment impact. In reality, sustainability is something simple: 'meeting our needs while not compromising the ability of future generation to meet theirs'[3].

The new paradigm, and the challenge of a developing country, is to continue with the social-economic growth while reducing drastically de energy consumption, especially the ones that come from fossil fuel.

Europe has been following a set of measures on reducing the energy consumption and increasing the implementation of renewable energy sources into the building sector. Therefore in 2020 the objective of the European Countries is a reduction of 20% in the primary energy consumption in all the economic sectors. Due to that commitment, in all member states were adopted national initiatives based on the European orientations.

Portugal follows those initiatives and implements energy reduction actions in all levels of the economy, but mainly in the building sector. These actions are necessary to implement a set of international agreements that were accepted by the government and political authorities.

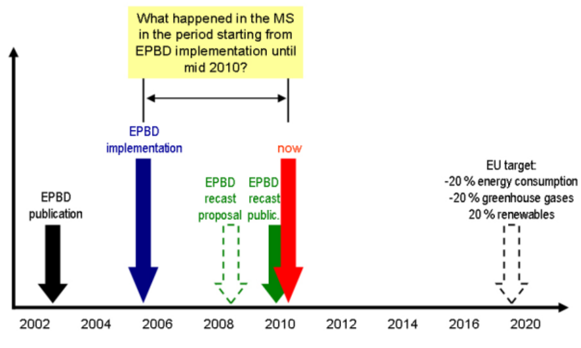

Fig. 1 - Diagram presenting the period of changes in national EPB procedures (source www.epbd-ca.eu)[4]

The energy performance certification (EPC) [5] appears as one of the measures designed to achieve a lower energetic consumption in the Portuguese energy panorama. With this action, it emerges a market of opportunities, that seem promisor at first sight, but rapidly was deteriorated as a result of a feral cannibalism and the attenuation of the technical quality. As a consequence the certification system is threatened and, even worse, problems to achieve the energetic goals for the following years are raised.

In this document it is shown a simple analysis of the market's potential associated to the Energy Performance Certification and opportunities of business, which may be in danger when confronted by a set of threats.

ENERGY AND BUILDINGS CONSIDERATIONS

Based in the energy consumption of the residential and services sectors (tertiary sector), the European Commission released in 2002 (EPBD) [6] the first of many directives with the objective of reducing energy consumption in these two building sectors, which represent 40% of all primary energy consumption around all Europe (Fig. 2). One more careful analysis shows that this last years' trend of the has remained pratically constantly [7].

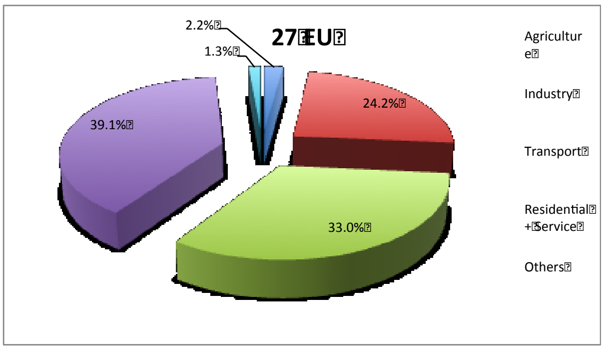

Fig. 2 - Primary Energy consumption Breakdown for 27 EMS in 2009 [8].

In Portugal, the energy consumption in the residential and office building sector represents approximately 30% of all energy used in 2009 [8] (Fig. 3). The European EPDB was transposed into Portuguese legislation in 2006 through three Decrees: SCE [5], RCCTE [9] and RSECE [10].

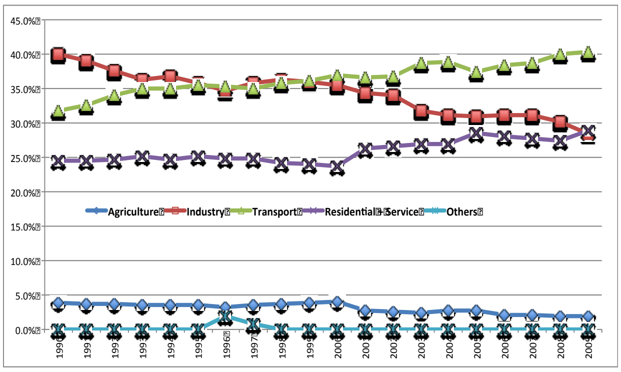

Fig. 3 – Total Energy consumption in Portugal [8]

The certification process initiated effectively in 2007, being implemented smoothly and completed in January of 2009, which means that, after this date, every building, regardless of its typology and size, had to have an energy performance certificate.

Number of buildings – potential certification process

In general and based on Censos 2001 information, there were 2.6 million of residential buildings [11], and in the last 15 years, were built in average 52 thousand buildings per year. Between 2001 and 2009 were built a total of 446 771 buildings [11], which tendency in the last years is shown in Fig. 4

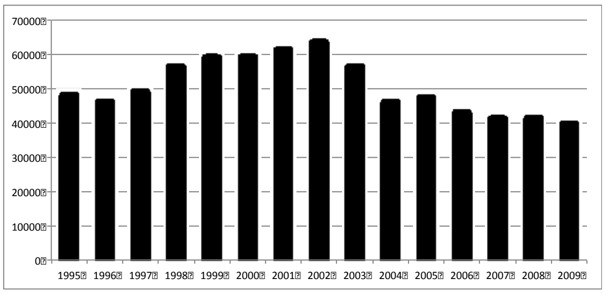

Fig. 4 - New buildings construction in last 15 years (source : Eurostat)

As mentioned in an analysis made by the ITIC[1] [11], based on Censos 2001, there were in Portugal about 3 160 043 buildings, 57% of these were build after 1971. At that time, 59% of the buildings don't required any refurbishing, while 38% required little interventions and 3% deep ones.

The Eurostat database (Fig. 4) and the published report made by ITTC shown that the Portuguese buildings are more, or less, 3.5 million.

[1] ITIC – Instituto Técnico par a Indústria da Construção

Those buildings will be applied the new EPC in the next years.§

EVOLUTION OF PORTUGUESE CERTIFICATION

In the last 3 years were made about 390 thousand certifications in Portugal (ADENE[2]). The following figure (Fig. 5) presents the evolution of certification in Portugal, being that is possible evaluates the weight of the Legal Conformity Declaration (DCR) and the Energy Performance Certificate (CE).

In general, it can be said that in the last months were made about 11 thousand certificates per month, basically 80% of them are existing buildings. Of all EPC, 10% was office buildings. According to ADENE in the years 2009 were issued 154 thousand EPC, and in 2010 it was only achieved the value of 120 thousand, in other words a drop of 20% relatively to the first year.

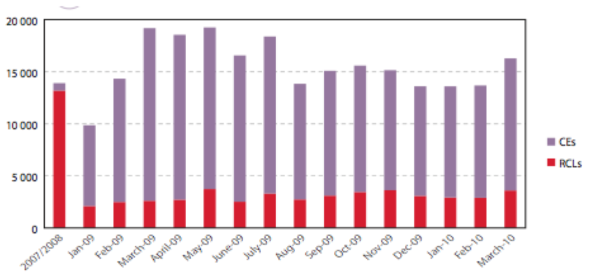

Fig. 5 - Number of Energy performance Certificates up to March 2010 [12]

The evolution of the last months shows a slowdown tendency of slowing down, but still, based in the existent building it means only 7,9% of the buildings is currently certificated, which means a very low portion of total built buildings in Portugal.

Based on the current evolution of certification, is forecasted more than 15 % of the total built buildings will be certificated until in March of 2013. Amore optimist approach might show around 600 thousand certificates, and in a negative scenario about 500 thousand certificates (EPC).

[2] ADENE - Agência para a Energia

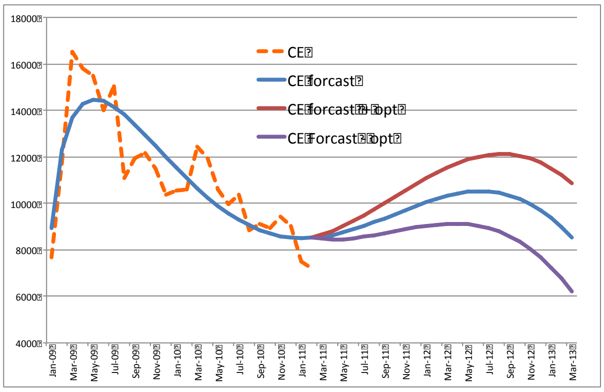

Fig. 6 - Evolution of Energy performance certification forecast till March 2013

In the optimistic and positive scenario, it is expected an average of 11 thousand certificates per month, in which 8 thousand are existing buildings and one thousand service buildings. These numbers owe to be considered to make the economic evaluation of the certification process.

SUSTAINABILITY OF THE CERTIFICATION

Direct incomes from the certification process

Generally, the price of certification in every member state changes significantly. Thus, the cost of a housing certificate can vary between 50 € in France and 900 € in Spain. Fig. 7 [13] shows a variety of prices that can be found around Europe for emission of an energy certificate.

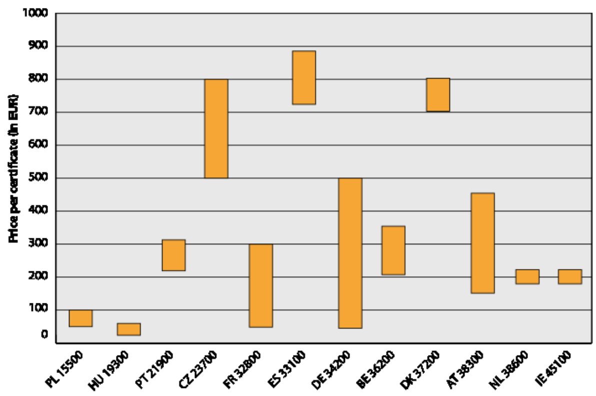

Fig. 7 - Range of prices of certificates in the 12 member States [13]

According to the document emitted by Concerted Action EPBD [4], in Europe the values of a certificate can oscillate between, 200€ and 600€ in average and in most of the countries, for the case of habitations, having no reference for the non-residential buildings. However, for the service buildings the practised values can reach 20 000 €. In the Portuguese case, the certificates' price for residential building is in average between 220 and 320 €. Based on the estimative of Fig. 6, it can be said that this market worth, in a direct way, between 2 and 3 M€/month, which might correspond to an average of 30 M€ annually.

In the case of office buildings, EPC can round the 2 500 €, based on values resulting from the information held by players of the national market. Therefore, this market represents in average 22M€/month, that is 260M€/year in a direct proportion.

This evolution represents a natural tendency of the market, without the need of much effort by the fiscal entities, to make the certification process more intense given its obligatory character and actual law placed since 2009 for all existing buildings.

Indirect incomes from Certification Process.

Associated to the certification process (EPC) the assessors can realise that there is a necessity of refurbishment derived of the inspections and audits to the buildings and HVAC systems (Heat Ventilation and Air Conditioning systems). In the case of residential buildings, it is estimated that the cost of interventions made to improve the certificated buildings can reach about 5 000 €/building [11]. The target universe of requalification (refurbishing) as a result of the certification process represents about 43 % of the residential buildings [11]. According to the ITIC represented, in 2008, a business target between 11 381 M€ and 14 300 M€, in the residential building sector. Recently gathered information on certification shows that of the total certificated buildings completed so far, 40 % of them need an intervention [12]. Based on the values observed by the ITIC, IEA[3] and the previous data presented above, we are in the presence of a value that goes up to 230 M€ annually.

About the non-residential buildings, the experience shows that about 50 % of the audited non-residential buildings need alterations/adaptation, or installation of Air conditioning systems (HVAC). Assuming an optimistic scenario in which only 25% of the noon-residential buildings need intervention, due to the indoor air quality (IAQ), they will need a new HVAC project design, plus an installation of a new HVAC system and respectively actions related to civil construction. In a general way, the annual value of the interventions can approach the 65 M€ for the HVAC project design and 1 130 M€ which include the installation of equipment and actions of civil construction.

[3] IEA – International Energy Agency

CONCLUSIONS

This work tried to show a simple perspective of the economic and social potential that can be taken from the energy performance certification in Portugal. This market, that can have an direct economic potential, in the next years, of 290 M€/year, as a result of the EPC action in the Portuguese residential and non-residential buildings. In an indirect way, and based on the values presented above, it is a market that can be evaluated annually 1 430 M€, between actions of reconstruction, refurbishment, including HVAC project design, equipment installation and actions of civil construction engineering.

Another aspect not mentioned so far, is the social impact that can result from this EPC process, since that it is an opportunity to reduce the strong unemployment rate in Portugal, giving some activity to the sector, which due to the actual conjecture, has been suffering an economic recession in a drastic way.

This last factor, including the economical aspects, could be more intensified if the competent authorities take action with the aim of compliance assurance. By hypothesis, if it were intensified the inspection features and the certification obligatoriness, and, if as a result of that actions, it increase of 50% the forecasts until March 2013, then the certification would represent an overall value of 2 145 M€/year.

If added to this value the social effects that come from a dynamic economy, the decrease of unemployment in the sector it will be possible, the relive of social security and the creation of national richness.

Not less important than the other aspects is the energy concern. Portugal is strongly dependent from outside energy supply and this EPC process will be an opportunities to reduce the energy dependency by means of the reduction of energy consumption that is beneath the EPBD process. This aspect was not very deep analyzed in this document but it is a crucial aspect for the Portuguese economy.

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CO_2 EMISSIONS, ENERGY AND THE GOVERNANCE OF THE COUNTRIES

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Abstract: We investigated a possible link among the governance practiced by some countries to CO 2 emissions and the use of energy by these countries. To achieve this goal, we selected a sample of data composed of variables from 54 countries, from 2000 to 2008, available at the World Bank website. We used the method of linear regression with panel data, and the method of structural equations in order to make a robustness test. The results of the two models converged and showed the existence of a statistical significant relationship between governance, CO 2 emissions and the use of energy.

Key-words: governance, CO 2 emissions, energy, linear regressions, structural equations.

1- INTRODUCTION

Economic, financial, social, institutional and environmental development are the larger goals desired by any modern society. However, it is noticed that the links among the dimensions mentioned, take place in a very heterogeneous global macro environment.

In terms of sustainable development and long term trends, it is noticed that the agents involved in these relations - countries, institutions and organizations - are adopting more efficient and ethical attitudes and practices to achieve their long-term and strategic goals. In this sense, we can think about a relationship among the concept of governance in the countries, with the improvement of their environmental and energy conditions.

In this context, we decided to investigate as the central question of our research whether for a heterogeneous group of countries their governance practices are related to their environmental and energy indicators.

Thus, in the second section we develop a theoretical framework where we seek to conceptualize what we mean by governance, linking it to the indicators of CO 2 emissions and the use of energy and electricity, in order to investigate possible relationships among these variables.

In the third section we develop the methodology that allowed us to link the indicators of governance, CO 2 emissions and use of energy, so as to make possible the acquisition of knowledge about these possible relationships.

In the fourth section we present the results. In the fifth section we analyze the results and made our final considerations.

2- THEORETICAL REVIEW

In our view, unethical conduct is the opening door for personal or organizational actions whose goal is to gain unfair advantages in view of the existing rules. This may lead to the degradation of the relations between individuals and organizations and possibly lead to corrupt conduct.

So we can understand that the corrupt acts stem from a state of degradation of values, judgments and behaviors that represent, albeit simplified, a way of thinking and acting of a part of society. In this sense, the exercise of trying to measure the levels of ethical conduct and corruption of a society presupposes the construction of a reductionist model that allows us to understand, at least in some depth, this complex phenomenon.

In a simplified manner, Transparency International created an index that enables the measurement of corruption levels throughout the world. To construct this index, research was done with executives gathered in events promoted by the World Economic Forum. These executives evaluate the governance practices of their own country. The results of these evaluations are compiled and presented on the Transparency International website.

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According to the concepts of this organization, large-scale corruption in public projects is creating, all around the world, serious obstacles to sustainable development, resulting in a significant diversion and loss of public funds needed for education, health and social programs, both in emerging and in developed countries.

The index constructed by Transparency International ranges from 0 to 10 points, where the value zero (0) indicates the absence of governance practices and the value of ten (10) indicate the highest level of such practices.

Thus, the corrupt act that was only seen as a moral hazard has become even more relevant because of the costs it imposes on several areas of the state (social, economic, institutional and policy). From that perspective, the ways to reduce the incidence of corruption cases can be: a) to adopt legislation contrary to the practices of illicit persuasion; and b) the implementation of good governance rules and codes of best compliance in the organizational structure of the countries.

Governance practices can have significant impact on the corruption problems, because they focus on four key concepts: a) equitable treatment given to institutions, individuals, and organizations; b) transparency of entrepreneurs, agents, and supervisory actions; c) assumed responsibility for the tasks and achieving goals; and d) compliance with laws, rules and forms of conduct accepted by society (i.e. La Porta *et al*, 1999).

Therefore, we see that many suggestions for reducing the level of corruption and for improving the ethical level of business, directly or indirectly involve concepts related to governance best practices. Thus, it is necessary to define the concept of the governance of the countries, and what impacts it can promote in CO 2 emissions and in energy use by the societies.

Governance is a variable of great complexity, which includes numerous perspectives, and allows a wide range of measurements and indicators (i.e. Kaufmann, 2005). With respect to the measurement of the countries` governance (i.e. Kaufmann *et al*, 2005) the concept of this measurement was expanded (i.e. Kaufmann *et al*, 1999(a) and 1999(b)) regarding the definition of the components that should be measured and analyzed in order to construct a governance index. So, they list the following groups of issues to research and construct the indicator of governance in each country: a) voice and accountability; b) political stability and absence of violence; c) implementation of governance (government effectiveness); d) regulatory quality; e) enforcement (rule of law); and f) control of corruption.

The capture of the state also may be related to the creation of obstacles to reform and modernize the states. The adjustment of the states to the current and dynamic scenario of the global economy demands greater efficiency of the public economic agent (i.e. Kaufmann *et al*, 2006). Moreover, the degrees of transparency and competitiveness, besides the structural formation of the state, determine the dividing line that separates the lobby actions from those of corruption.

Concerning this point the countries´ elite captures the states "to dictate the rules of the game" which gives to the facts apparently illegal, the appearance of manifestations of "legal acts of corruption" instead of "illegal acts of corruption " (i.e. Kaufmann *et al*, 2002).

At the same time, we realize that the global business environment pointed to an increase in the importance of some aspects like ethics, corruption and governance practices concerns. In this context, it is important to highlight that the process of globalization has promoted the emergence of a network of links between economic, political, institutional, social, cultural and environmental realities, with development variables, in many different countries.

Thus, there is no way to delete the aspects related to business ethics, governance mechanisms and forms of corruption, from the list of relevant and critical issues that are inserted in the process of globalization. Similarly, no one can refute that there is a strong conceptual relationship between these variables and the long-term sustainable development.

In relation to sustainable growth, and in accordance with the definition given by the Brundtland Commission report, in World Commission on Environment and Development of 1987, this is conceptually the growth that meets the needs of present generations without compromising the ability of future generations to meet future needs.

We extended the relationship between governance and sustainable development for a long-term trend, cause only sustainable development can promote the finding of a higher quality of life at the moment and in the future (i.e. Detr, 1999).

Regarding the CO2 emissions, the Kyoto Protocol, signed in 1997 by 39 countries, established that emissions of carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride were to be controlled. Since then, the secondary market of carbon has grown very much, and a great number of countries joined the Protocol.

In our perspective, the concept that the CO2 emissions are related to the growth of the gross domestic product of countries (i.e. Bengochea-Morancho *et al*, 2001) and it allow us to infer that these variables are linked to the governance of the states.

By the other hand, there is a link between the quality of governance of the state and the reduction of CO2 emissions because the changing in the energy matrix depends on the intervention by the state (i.e. O'brien *et al*, 2007).

So, we decided to investigate the relationship between the level of governance for countries and the emission of CO2, that was used as an indicator of the variable, quality of climate and environment variables. We assumed that level of governance should be negatively correlated with CO2 emissions.

Also, there is a problem of technology transfer and only with such transfer, can the poorest countries use their natural resources to generate energy and break the cycle of underdevelopment (i.e. O'brien *et al*, 2007). Similarly the availability of energy is the most important factor in economic growth (i.e. Barro, 1996). Every country should strive to be more efficient in its the use of energy to achieve sustainable growth (i.e. Barro, 1996).

In poor economies, for a increase of 1% in economic growth to occur, an increase of more than 1% in energy use is needed (i.e. Mahmood, 2009) and (i.e. Huang, 2008). In Europe, from 1990 until 2002, according to EEA (2008), there was economic growth of 2.2% relative to growth in energy consumption of 0.5%. These indicators are linked to the pursuit of energy efficiency.

Developed countries have an ethical responsibility to reduce energy consumption by promoting programs of energy conservation and energy efficiency (i.e. Dernbach and Brown, 2009). Thus, our search for a relationship between the level governance in countries and the level of improvement with regard to energy management and sustainable development is consistent with the work of the mentioned authors (i.e. Dernbach and Brown, 2009).

To investigate such a potential relationship, this study includes two indicators of the energy management variables. The first indicator measures the total energy consumed in terms of kg of oil per dollar of income per capita in one year. The second indicator measures the total amount of energy consumed per dollar of disposable income per capita in one year.

The total expenditure for energy is used as an indicator of a possible acess to energy sources. And, the use of electricity is employed as an indicator to measure progress in moving toward less–polluting renewable because most probably the largest supply of power will be derived from the use of renewable energy at the source of the power generation.

We also used some economic variables to control the possible effects of the impacts caused by these economic variables in governance, in environmental variable and in energy variable. We include GDP growth and income per capita, which are directly related to the growth of wealth of the nation and its citizens, as variables that represent the countries` development. We also included the gross capital formation with regard to the potential infrastructure that the society has, to serve as a support for future projects, and to implement sustainable economic growth.

So, in this article we try to associate the governance variables, to some proxies of sustainable development such as CO 2 emissions and energy and electricity use. Then, we elaborate the hypotheses to be tested in this research:

H1: We believe that there is a negative relationship between higher countries` levels of governance and indicators of better environmental behavior, explained by low CO2 emissions. The expectation of the authors is that the existence of better management structures and better institutions, can be associated with the ability to develop better processes of production and can be aligned with best standards of sustainable development;

H2: There should be a positive relationship between higher levels of governance and higher energy consumption and higher electricity consumption. The authors considered that fairer and more equitable societies, besides the existence of tighter controls and more efficient state management, must be associated with greater access to energy and electricity consumption.

3- METHODOLOGY

Our research is of an exploratory nature. We seek to understand the relationship between the levels of governance practices of the countries, and the energy use and environmental variables of these nations. Therefore, initially, we collected the secondary data from the sites of the World Bank and Transparency International for our empirical investigations. The research period ranges from 2000 to 2008.

The universe is composed of 228 countries. We included a set of 54 countries in the sample investigated.

To construct this sample, we selected the countries that have available more than 70% of the data surveyed in the years under investigation. Aiming to verify whether there are relationships between the levels of governance of the countries and the energy and environmental variables of these countries, we used the method of linear regressions with panel data, following:

$$CPI = \beta_0 + \beta_1 * CO_2 + \beta_2 * eletpowcons + \beta_3 * eneruse + \beta_4 * gcf + \beta_5 * gdpgrowth + \beta_6 * gnipcppp + \varepsilon$$

Where:

$CPI = level\ of\ governance\ of\ each\ country;$

$\beta_0 = linear\ coeficient\ of\ the\ linear\ regression;$

$\beta_i = coefficients\ of\ the\ variables,\ where\ 6 \le i \le 1;$

$CO_2 = CO2\ emissions\ (tons.\ per\ capita);$

$eletpowcons = eletric\ power\ consumption\ (KWh\ per\ capita);$

$eneruse = use\ of\ energy\ (Kg\ of\ oil\ per\ capita);$

$gcf = gross\ capital\ formation\ (billions\ of\ dólares);$

$gdpgrowth = anual\ internal\ product\ growth\ (\%);$

$gnipcppp = income\ per\ capita \begin{pmatrix} parity\ purchase\ power \\ - US\ dollars\ per\ year \end{pmatrix};$

A robustness test of the results was made by running the method of structural equations. We constructed the equations based on the idea that the country`s level of governance can have an endogenous relationship with all the other variables of the research. The schematic summary of the equations is shown below:

$$CPI = f(CO_2, eletpowcons, enerusers, gcf, gdpgrowth, gnipcppp)$$

$$CO_2 = f(CPI)$$

$$eletpowcons = f(CPI)$$

$$gcf = f(CPI)$$

$$eneruse = f(CPI)$$

$$gcf = f(CPI)$$

$$gdpgrowth = f(CPI)$$

$$gnipcppp = f(CPI)$$

4- RESULTS

To utilize the linear regression using ordinary least squares, we first need to apply normality and heteroscedasticity tests. We employed the Kolmogorov-Smirnov and Shapiro-Wilk tests to check the normality of the variables. All the variables passed in these tests with a significance of 0,001%.

Subsequently we ran the equality test of variances, using the Bartlet, Levene and Brown-Forsythe methods. After, we constructed the panel data and applied the method of linear regression using the OLS. In Table 1 we can observe the results of normality and homoscedasticity tests mentioned above.

	Average	K-S	S-W
CPI (n = 340)	5,4962	0,119 (0,0000)	0,921 (0,0000)
CO2 (340)	6,4470	0,016 (0,0000)	0,923 (0,0000)
eletpowcons (340)	5664,6000	0,165 (0,0000)	0,798 (0,0000)
eneruse (n = 340)	3062,9941	0,119 (0,0000)	0,896 (0,0000)
gcf (n = 340)	21,8676	0,116 (0,0000)	0,929 (0,0000)
gdpgrowth (n = 340)	3,92	0,142 (0,0451)	0,913 (0,0451)
gnipcppp (n = 340)	17339,7235	0,147 (0,0000)	0,914 (0,0000)

Bartlet	Levene	Brown-Forsythe
N.A.	N.A.	N.A.
N.A.	N.A.	N.A.
7,9021 (0,0481)	7,8477 (0,0000)	5,7297 (0,0000)
11,9117 (0,0026)	13,5507 (0,0000)	16,1504 (0,0000)
N.A.	N.A.	N.A.
N.A.	N.A.	N.A.
0,3044 (0,8588)	0,0046 (0,9954)	0,0927 (0,9114)

Table 2- Data were presented with their p-values. The symbols * and ** identify which tests of homoscedasticity were performed with fewer degrees of freedom, respectively 5 and 2 degrees.

We also tested whether there is evidence of multicollinearity among the variables of the sample, through the VIF test. The results of all variables, in all models, were less than 2.0, indicating the absence of multicollinearity for the data investigated. Therefore, after performing all the aforementioned tests, we applied the method of linear regression and we obtained the results presented in Table 2. One model included the White heterocedasticity correction and the other model didn´t include this correction.

Dependent variable:CPI	Without White Heterocedasticity Correction	Without White Heterocedasticity Correction
CO2	- 0,0740** (0,0048)	- 0,0740** (0,0016)
eletpowcons	5,34E-05* (0,0559)	5,34E-05* (0,0953)
eneruse	- 0,0001 (0,1649)	- 0,0001 (0,1381)
gcf	- 0,0034 (0,8053)	- 0,0034 (0,7542)
gdpgrowth	- 0,0538** (0,0177)	- 0,0538** (0,0105)

gnipcppp	0,0002**** (0,0000)	0,0002**** (0,0000)
C	2,7848**** (0,0000)	2,7848***** (0,0000)
Numbers of observations	340	340
R^2	0,7818	0,7818
R^2 adjusted	0,7778	0,7778
DW	2,3075	2,3075
Log Likelihood	- 545,0841	- 545,0841

Table 2- Results of linear regression with panel data with their respective p-values, with and without White Heterocedasticity Correction. The symbols *, **, ***, **** indicate, respectively, values statistical significant at 15%, 10%, 5%, 1% and 0.1%.

Subsequently we conducted residuals tests of normality and homoscedasticity. The results are shown in Table 3.

Residuals tests	Normality (J-B)	Test of Hypothesis: Mean = 0 (t statistic)
Dependent variable (CPI)	16,9951**** (0,0002)	1,89E-14 (1,0000)

Homocedasticity (Bartlet)	Homocedasticity (Levene)
3,7822 (0,2860)	1,6182 (0,1849)

Table 3- Results of linear regression with panel data with their respective p-values in parentheses. The symbols *, **, ***, **** indicate, respectively, values statistically significant at 10%, 5%, 1% and 0.1%

We used the Wald test to check the existence of nil values for the coefficients. The hypothesis was rejected at a significance level of 0.01%.

We performed a robustness test of the results obtained. We applied the method of structural equations to confirm the previous results. The results are presented in Table 4.

Model of structural equations	Factors	Covariances (p-values)
CPI-gcp	- 0,315	- 0,996 (0,319)
CPI-gdpgrowth	- 0,640	- 3,351**** (0,000)
CPI-gnipcppp	24362,47	14,113**** (0,000)
CPI-eletpowcons	2421,32	6,367**** (0,000)
CPI-CO2	- 0,486	- 1,644* (0,100)
CPI-eneruse	361,01	2,529** (0,011)
CMIN	1571,07 (0,000)	
RMSEA	0,460 (0,000)	
df	15	
Number of observations	491	

Table 4- Results of structural equation model with their respective p-values in parentheses. The symbols *, **, ***, ****, indicate values statistically significant at 10%, 5%, 1% and 0.1% respectively.

5- ANALYSIS OF THE RESULTS AND CONCLUSIONS

Initially it is important to report that the income per capita was, in average, $ 17.811,19 (seventeen thousands, eight hundred and eleven North American dollars and nineteen cents) per year, and the average GDP growth in the investigated sample was 3,76% per year. The governance index average within the period investigated, was 5,42 and ranged from 5,33 to 5,51. It increased in almost all the period, and the value of 2008 was 5.47. So, the data show the possibility to improve the good practices of governance in the countries throughout the world.

Analyzing the results of the relationships found with the method of the linear regressions with panel data, we conclude that higher levels of governance are associated with lower CO2 emissions, higher energy and higher electricity consumption, as we initially expected.

Thus, we believe that growth in the level of governance, which we can say that is a secure and increasing tendency in the period analyzed, should be accompanied by a reduction in CO2 emissions. There is a need to increase the number of projects with lower emissions of polluting gases, and countries should pay attention to the development of secondary markets for securities linked to CO2 emissions. We know that countries have growing needs in increasing their energy supplies. Since it is unlikely that there will be observed an increase in the supply of fossil fuels in the future, even at very high prices, we will need to exploit alternative energy sources as a solution to this growing demand.

The test with the method of structural equations used by the fact that this research has the characteristic of an exploratory research, confirmed the results found with the method of linear regression. With statistical significance we observed the negative relationship between better governance and low CO2 emissions. We also confirmed the positive relationship amongst better governance and higher consumption of energy and electricity.

We consider that the trend for improvement in governance levels seems to be increasing and consistent, and that there is clear evidence that this growth is closely associated with the concepts of sustainable development. So, we associate the growth of governance levels of the states with the diminishing of CO2 emissions, with the increasing access to energy sources and with the increasing in clean energy supply. Thus, we expect this trend to be a continuous and resilient.

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VALUE AND GOVERNANCE OF THE BRAZILIAN CORPORATIONS: HOW IS THE RELATIONSHIP BETWEEN THESE VARIABLES?

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Abstract: This study estimated the quality of governance practiced by a significant sample of Brazilian publicly traded companies between 2002 and 2006, and related it to risk, performance and value. Hausman test was used and afterwards the structural equations method was applied and constructed several models involving the relationships among governance; performance measured by *roe* (return on assets) and *ets* (ebit-to-sales); risk measured by the *wacc* (weighted average cost of capital), and value measured by *mts* (market-to-book sales) and *mtbv* (market-to-book value). Statistically significant results between higher levels of governance, lower risk, better performance and higher value were observed.

Keywords: Governance, risk, performance, endogeneity, and structural equations.

1 – Introdution

The growth potential of organizations is the most relevant issue for investors. This potential is linked to the amount of resources available for investment and the ability to generate a stream of attractive returns for investors. Besides, the perceived safety on investment and the low cost to monitor it are also important issues in the globalized markets.

From the perspective of monitoring, research on corporate governance has added new management dimensions related to the control levels and policy incentives provided by corporations, which become relevant in investment decisions.

It this investigation is was assumed that the improvement of governance practices is associated with the development of better organizational structures and the search for a better dynamic in the firm´s operations, which make it possible to upgrade performance, decrease the risks and, consequently, increase the firm´s market value.

As managers objective is to maximize the value of an investment for shareholders and assuming that this is reflected in the growth of the value of the company, these managers should seek to reduce the cost of capital and improve organizational performance, as intermediate goals. In this context, the exercise of governance best practices becomes an instrument that leads to improving decision making and more efficient controls, providing higher management efficiency and making possible for companies the achievement of the intermediated goals, mentioned before.

Although many authors have already investigated the relationship between governance and value, in this paper were investigate how the adherence to best practices of corporate governance relates to the risk, performance and value of Brazilian companies. Our main interest is to investigate if governance impacts the value by one or two mediating variables - risk and performance - ; how it impacts; and if exists a direct relationship between governance and value, even with the indirect influences of governance in risk and performance.

In the second section was developed a theoretical framework in order to investigate the relationships between risk, performance and value indicators and the governance practiced. In the third section was presented the research methodology. In the fourth section was furnished the results and their analysis. The conclusions were given in the fifth section.

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2 – THEORICAL REFERENCES

2.1 – Quality of governance practiced

The level of governance implemented in a company can be estimated by some characteristics or practices, according to Black, Jam and Kim (2006), Leal and Silva (2005), for example. In this research was constructed a broad indicator of governance using some questions of the Brazilian Corporate Governance Institute indicator of governance, utilized in 1995 to select the company with the best practices of governance in Brasil. Some questions of the two governance indicators developed in Black, Jam and Kim (2006) and Leal and Silva (2005) were also used.

Recent studies have analyzed a series of aspects related to governance, amongst which, the following should be highlighted: a) the importance of the ownership and control structures; b) the level of disclosure of information; c) the existence of private benefits of control; d) the quality of auditing; e) the existence of a supervisory board and committees; f) the board composition; g) corporate compensation policy; h) the existence of activist institutional shareholders; i) the possibility of tag-along rights for minority shareholders; j) the existence of anti-takeover provisions; k) the degree of minority shareholder rights protection; and l) the level of development of financial markets. Thus the quality of governance practiced by firms was measured using a broad governance index. The components, rationale, and scoring criteria of the governance index used in this research can be found in Lameira (2007).

This theoretical framework provides an opportunity to establish stages of development of governance practices by companies. Although the themes presented in the previous paragraph are broad, they allow to qualify the governance practiced by the companies.

2.2 – Performance, value and risk variables

In the following paragraphs was presented the concepts and indicators of the dependent variables of the study - performance, risk and value - .

Performance: Represents the companies` performance dimension, measured by some accounting, financial and market indicators. These indicators were obtained from the financial statements, accounting reports, corporate information and market data related to the company shares. The ratios *return on equity* (*roe*) and the *ebit-to-sales ratio* (*ets*) were used, they were calculated between the operational profit and the net value of revenues, as performance indicators.

According to Bhagat and Jefferis Jr. (2005), the variable (*ets*) was chosen for being the most stable indicator of performance over time, and the profitability index (*roe*) was chosen because it is a relevant measure of performance commonly used in market.

Value: Represents the companies` value dimension also measured by some accounting, financial and market indicators obtained from the financial statements, accounting reports, corporate information and market data related to the company shares. The *market-to-sales ratio* (*mts*) was choose because it is the most used indicator of value in this kind of research and because of the statistical results obtained by Black *et al.* (2006). The *market-to-book-value* (*mtbv*) was also chose because of the results in Ashbaugh, Collins e LaFond (2004) and in Black *et al.* (2006).

In a restricted vision, the authors who investigated the relationship between governance and firm value, eventually infer, even indirectly, about the reduction of risk or the improving the performance of the company. Thus, if the value of the firm is defined theoretically as the sum of future cash flows that the company is able to generate, discounted to present value by the weighted average cost of capital, then the reduction in the risk of the company directly impacts the weighted average cost of capital and therefore affect the value of the enterprise. By the other hand, the idea of governance best practices is associated with better control systems and compliance, more efficient incentives policies, and this creates the expectation that such companies could best performances, and this should also result in increasing the value of the company.

Risk: Represents the companies´ risk dimension. Regards this issue, Ashbaugh *et al.* (2004) investigated the relation between governance and the cost of equity; Chen, Chen e Wei (2004) and Zhou (2005) studied the relation between governance and the cost of capital; Can-Lau (2001) searched the relationship between governance and the cost of debt. In Can-Lau (2001), the risk variable were defined as the companies´ weighted average cost of capital (wacc). Significant statistical results in the association between risk and governance, as were observed in the studies mentioned before are expected to find in this research too.

At this point, a theorical framework containing some relevant academic views on the relationships involving performance, value, risk and governance are developed.

2.3 – Governance, performance and value

With regard to this subject, Bohren and Odegaard (2006) developed a typology study relative to governance and value variables, which includes as differentiated factors, the direction of causal relationship (governance to value or value to governance), and whether the relation is from one variable to the other or reciprocal. In addition, they pointed out the importance of the issues - endogeneity, reverse causality or spurious relations - and emphasized that the multiple linear regressions with panel data is the most used method of study, and the structural equations is the most appropriate.

Bai et al. (2002) showed that, in the Chinese markets, investors pay a premium (41 to 67% of the market value of the shares), for companies with governance best practices. They also found a significant statistical relationship between governance and value. Klapper and Love (2002) observed statistical evidences between governance, performance and value, and perceived that governance has an endogenous feature, and is most important in places with weak legal protection. Brown and Caylor (2004) concluded that companies with best practices are more profitable, are better evaluated by the market and pay better dividends.

Beiner et al. (2004) perceived evidences of reverse causality going from the value for governance, by using structural equation systems in order to avoid problems of endogeneity.

Durnev and Kim (2005) found that the quality of governance is determined by growth opportunities, the need of foreign capital and the concentration of ownership. In addition, they ratified the perception of Klapper and Love (2002) that governance and transparency are more important in markets with low legal protection. From another perspective, Black et al. (2006) achieved robust results linking governance and value using an exogenous index.

In Brazil, Silveira (2004) concluded that performance influences the level of governance and highlighted that company performance impacts the ownership structure, and that this structure does not appear to be endogenously determined by other corporate variables.

Silva (2002) noted that there are some significant signs that the structure of control and ownership has an impact on the market value of companies. It also found that the higher the concentration of ownership, or the higher the concentration of rights to cash flow by the controller, the lower the value of the company.

Finally, Leal and Silva (2005) confirmed the statistically significant relationship between governance and value in Brazilian companies and detected that the results related to the issues of disclosure are stronger than the other aspects of governance. They also observed that there is a strong concentration of ownership arising from the indirect control structures like pyramidal structures, and the extensive use of shares without voting rights.

2.4 – Governance and risk

Regarding this issue, Drobetz *et al.* (2003) obtained significant statistical results for the influence of a governance index on the difference between the best and worst governance portfolios. In another test, they verified the extent to which firms' betas and the governance index explained share returns and also obtained significant statistical results for the coefficient related to the governance index. They also achieved significant statistical results for the governance index when using the proxies – dividend yield and the price-earnings ratio – as dependent variables, controlling the risk and the growth of the dividend yield (in the case of the latter) by using the rate of growth *g* (in accordance with Gordon's model). All the coefficients of the governance index used in the tests were statistically significant, which were aligned with initial expectations.

Chen, Chen and Wei (2004) identified that governance practices relative to disclosure were negatively related to the cost of capital. However, they observed that, in Asian emerging markets, diminishing the risk of minority shareholder expropriation was a more significant factor in reducing the cost of capital than improvements in disclosure practices.

Ashbaugh *et al.* (2004) found statistically significant results for the negative relation involving governance practices and the cost of equity, thus confirming the theory, and another negatively significant relation involving the broad index, the reduction in the cost of equity and the firms' beta.

Cremers and Vinay (2005) investigated how external mechanisms (takeovers) and internal mechanisms (shareholder activism) linked to governance were related to the returns on portfolios of high and low levels of governance. They found that the portfolio that was most vulnerable to takeovers generated a return 10 to 15% above market returns, when an institutional investor had a significant stake in the firm's capital. On the other hand, firms with better internal controls generated returns 8% higher than the market average when this characteristic was associated with a great possibility of the firm being vulnerable to a takeover.

Derwall and Verwijmeren (2007) reported that better governance levels are associated with lower implicit costs of capital, lower impacts from systematic risks and lower specific risks of the companies.

In order to consolidate the theory and concepts developed in this research, it is necessary to enumerate and describe the control variables of this study, which is done in the next section.

2.5 – Control variables

Various control variables were included in this study in order to use adequately the methods proposed. The objective of this procedure was to obtain results that could adequately give measures and directions of the relation between governance and firm risk. These control variables included: 1) capital intensity (fixed) calculated as the ratio of permanent to total assets; 2) operational leverage (opl), calculated as the ratio of operating results to operating revenues; 3) the relation between indebtedness and capital (*de*), calculated as the ratio of net debt to capital stock; 4) the company's size (size), calculated as the logarithm of the company's net operational revenues; 5) the level of investments (inv), calculated as the ratio of the the investment account in assets and stockholders' equity market; 6) financial leverage (finl), calculated as the ratio of profits per share to operating results; 7) an index of shares' market liquidity (liq) calculated in the Economática databank; 8) company experience (exp) calculated as the logarithm of the number of months that the company has been publicly-owned and has had its shares listed on the stock exchange; 9) size of the board (bod) calculated as the algorithm of the board's size; 10) domestic private sector (pri) control dummy – 0 if its state-owned and 1 if it has another structure of private sector national control; I1) *ADR* 23 (*adr*23) dummy – 0 if it does not have a Level 2 or 3 ADR program and 1 if it does; 12) N2 and NM dummy (lev2nm) – 0 if it does not have and 1 if it does participate in the Level 2 or New Market of the Differentiated Procedures of Corporate Governance of the São Paulo Stock Exchange; 13) N2 e NM x *ADR*23 (lev2nmadr23) dummy – 0 if it does not have and 1 if it does have both advanced levels of ADR and Differentiate Procedures of Corporate Governance programs; 14) percentage of common stock owned by the controller (com), calculated as the ratio of the amount of common stock owned by the controller to the company's total common stock; 15) percentage of the total capital owned by the controller (cap) calculated as the ratio of the number of shares owned by the controller to the company's total amount of shares.

3 – METHODOLOGY

3.1 –Aspects of the research

The universe was composed of Brazilian publicly traded non-financial companies registered with the CVM as public companies on 31.3.2002, 31.3.2003, 31.3.2004, 31.3.2005 and 31.3.2006. The publicly traded companies during the years mentioned numbered 820 (2002), 780 (2003), 695 (2004), 627 (2005) and 620 (2006) respectively. Of this total, and on the same dates, 412 (2002), 391 (2003), 362 (2004), 355 (2005) and 339 (2006) companies had their shares listed for trading on the São Paulo Stock Exchange.

The non-probabilistic sample investigated was composed solely of companies whose shares, listed on the São Paulo Stock Exchange, had liquidity and volatility different from zero (0) during the month of April in at least two of the following years: 2002, 2003, 2004, 2005 and 2006, or made their initial public offering in this period. The study chose April because it is immediately after the time of year when public companies publish their annual balance sheets and hold their annual shareholders meetings. The second criterion used was to include only those companies whose share volume was equal to or greater than 0.01% of the financial volume of trades involving the shares of the most traded stock on the São Paulo Stock Exchange during the period under consideration. At the end, the sample contained 99 companies, some of which entered the sample after 2002. Some of these companies entered in the sample during the study period because they had their initial public offering (IPO) after 2002. So the sample was composed by 81 companies in 2002, 2003 and 2004, 89 in 2005, and 98 in 2006. Our database consists of about 20000 data.

The study used secondary data obtained from Economática´s informatized data base and through documental research in the FS (Financial Statements) and AR (Annual Reports) obtained from the CVM and São Paulo Stock Exchange websites and, in the case of companies with ADR programs, from the companies themselves and the J.P.Morgan Bank. Based on the analysis of these documents questions were selected to construct the governance index. The answers to the questions had to be of a YES/NO kind. When the answer was YES, 1 point was scored and when it was NO, the score was 0 (zero). Finally the total number of points attributed to each of the companies surveyed was summed.

The limitations of the research included: a) problems of endogeneity in the variables assumed to be exogenous. In order to deal with this the research used the Hausman test to verify if the structural equations method is more appropriate;

b) there is a degree of uncertainty in measuring the index of governance proposed to be used in this research; c) there may possibly be non-normalcy problems in the distribution of the independent variables, but these can be controlled by transformations in the variables that do not pass the normalcy test; d) there may be significant correlations between the independent variables. In this case transformations can be made in these variables (using a natural or neperian logarithm, the inverse function or the square root), or the variable may even be excluded; e) there may be problems regarding the identification of causality or even a relation of reverse causality between governance and risk, that can be minimized using the structural equations method; f) the non-intentional omission of important variables in the models that serve as studies may occur. In order to solve this problem a review of the literature was undertaken which sought to include all the important variables related to the subject; g) there may be difficulties in identifying a time trend, but panel data covering a period of five consecutive years can be used to nullify this effect; and h) there may be problems regarding the selection of the sample, given that the public company segment may include less riskier companies.

About the problem regarding the sample selection bias, Heckman (1979) points out that the selection of non-random samples causes a bias in the results of investigations that seek to estimate coefficients of relationship between variables. The mentioned author discusses the problem of sample selection as a specification error of the variables. Heckman (1979) also estimates the coefficients by the use of simple regressions in two stages as a way to mitigate the problem when using the method of least squares. According to the author, the problem of sample selection can be shown in two ways. At first, the choice of variables or individuals to be included in the study could promote a self-selection and be biased. In the second possibility, the personal choices of the researcher insert a bias in the same sense of self-selection.

Therefore, problems in selecting the sample in our research appeared, given that the segment of public companies can include firms less risky than the majority of firms of the economy. It is assumed that such companies need to promote an improvement of their management, in order to do their IPO. So, issues related to the quality and transparency of information, and investor relationships, become much more relevant than they are for private companies. These factors become decisive for such companies to raise funds in the capital market. These capital market resources are fundamental to a significant reduction in the cost of capital of the public companies.

3.2 – Statistical modeling

3.2.1 – Hausman test and endogeneity

Given the possible existence of endogeneity in the relationships involving governance and the other variables (risk, performance and value), the authors performed the Hausman test in order to verify its existence.

The Hausman test begins with the estimation of linear regression equations that best fit the value variables (*mts*) and (*mtbv*) –. These regressions included the governance variable (*igc*), among the explanatory variables and generated residuals. Such residuals are tested in an regression whose dependent variable is the (*igc*), in order to check whether these residuals are statistical significance as an explanatory factor of the (*igc*). If it happens, evidences were found to conclude that there is an important information contained in the fact of considering the relationship between governance and value as an endogenous relation.

Several models relating the variables of risk, performance, governance and value were constructed in order to build a body of evidence on such relationships. For this, either exogeneity or endogeneity were took for granted. Different variables for performance and value and different number of control variables (with and without control variables) were also utilized. The results of these models are shown in Table 2.

3.2.2 – Model study using the structural equations method

If the Hausman test indicates endogeneity in the relationships between the variables, and based on the literature, especially in Cho (1998), Bhagat and Jefferis, Jr. (2005) and Bohren and Odegaard (2006), a system of structural equations should be build, so as to measure the relationships between governance, risk, performance and value.

The risk indicator was the sqr (*wacc*), the performance indicators were log (*ets*) and sqr (*roe*), the governance variable was sqr (*igc*) and the value variables were log (*mts*) and log (*mtbv*). All of these variables have normal distributions.

Thus, the following set of equations covering governance, risk, performance and value were established:

Equation 1: $Performance = f_1(Risk, Governance, Value, \varepsilon_1)$

Equation 2: $Risk = f_2(Performance, Governance, Value, \varepsilon_2)$

Equation 3: $Governance = f_3(Performance, Risk, Value, \varepsilon_3)$

Equation 4: $Value = f_4(Performance, Risk, Governance, \varepsilon_4)$

Where:

$\varepsilon_i = error\ term\ of\ each\ equation$

In which:

$i = \{x \in \Re,\ 1 < x < 5\}$

3.3 – HIPOTHESES

From the theoretical framework presented, the following hypotheses were tested:

1. Higher levels of corporate governance practices are associated with lower levels of risk. Negatively correlated (-). It is expected that the results of this research are aligned to the results obtained by Drobetz et al. (2003), Chen et al. (2004) and Ashbaugh et al. (2004) among others;

2. Higher levels of corporate governance are associated with better performance. Positively related (+). Estimated to find relationships that reinforced the results founded by Bai et al. (2002);

3. Governance has a direct impact on increasing the value of the company. Positively related (+). It is expected that the results of this research are aligned with the results obtained by Black et al. (2006);

4. There are indirect effects of governance in value incurred by the variables risk and performance. This is the expectation in this research. The authors believe that governance directly affects the variable value, but also has an indirect effect through mediating variables of performance and risk;

5. The governance variable has characteristics of endogeneity. This is also a hypothesis in line with the assumptions focused on Cho (1998), Bhagat and Jefferis, Jr. (2005) and Bohren and Odegaard (2006) which led the authors to apply the Hausman test.

4 – ANALYSIS OF RESULTS

4.1 – Governance index

Regarding the governance index, in the five years, the corporate scores ranged from 6.4 to 17 points, with an average of 9.86 and standard deviation of 2.02. It was observed that the sample has a low average and an increasing dispersion. These numbers seem to indicate an increase in differences in the quality of governance, among companies, even though the average score is still very low. This phenomenon can be explained, in part, by the entry of new companies in the capital market, in recent years. These companies invested in higher levels of governance practices.

4.2 – Analysis of the results of Hausman test

The following set of equations were used:

$$mts = \beta_{11} + \beta_{12} \times V_i + \beta_{13} \times igc + \varepsilon_1 \quad \text{(equation 1)}$$

$$mtbv = \beta_{21} + \beta_{22} \times V_i + \beta_{23} \times igc + \varepsilon_2 \quad \text{(equation 2)}$$

$$igc = \beta_{31} + \beta_{32} \times V_i + \beta_{33} \times [resíduo\ mts] + \beta_{34} \times [resíduo\ mtbv] + \varepsilon_3$$

(equation 3)

Where:

$\beta_{11}, \beta_{21}\ e\ \beta_{31} = constants\ of\ the\ multiple\ linear\ regressions;$

$mts, mtbv\ e\ igc = value\ and\ governance\ variables;$

$V_i = control\ variables;$

$\beta_{33}\ e\ \beta_{34} = coeficients\ of\ residual\ variables\ of\ equations\ 1\ and\ 2;$

After applied the mentioned method the following outcomes were obtained:

$$\beta_{33} = -22{,}258\,(0{,}0000) \quad e \quad \beta_{34} = -19{,}564\,(0{,}0000)$$

The results of $\beta_{33}\ e\ \beta_{34}$ shown that exists relevant information in considering the endogeneity in the relationship among the investigated variables. So, the apropriated method to investigate the relationships among governance, risk, performance and value is the structural equations.

4.3 – Analysis of the results of the tests with structural equations

The method of structural equations was used in order to seek correlations between the variables cited before, including in the investigation, the characteristic of endogeneity in the relationships. Another reason to use that method was to make an effort to avoid the problems of reverse causality.

Eighteen study models were constructed and grouped into four structural configurations, differentiated from each other, sometimes by the variables entered, and either by the types of relationships assumed between these variables. The estimation methods were also switched, having been applied the maximum likelihood and the generalized least squares method.

In models 1 to 4, the governance was admitted as a variable that only cause an effect on mediating variables - risk and performance. Thus, in each model, four of the five relations (governance-risk; governance-performance; governance-value; risk-value; performance-value) were restricted, in order to meet the weight of the relation between the two variables that had the relation not restricted. The coefficients represent the weight of the relations investigated under the premise that such relationships are exogenous.

The negative relation between governance and risk and between risk and value, and the positive relation between governance and performance confirmed the hypothesis originally assumed. Only the relation between performance and value (using the performance variables - *ets* and *roe*) showed unexpected results. Perhaps the reason is that the operating results were being generated by highly leveraged companies. Thus companies with higher operational results but with a decrease in market value were found. By the other hand, from these results (using roe as a performance indicator) can be learn that firms with higher margins had smaller market values. This is consistent with the fact that companies with smaller amounts of equity and riskier projects, have opened capital recently. These companies have higher margins and lower market values, which is coherent with the relationship found. All results were statistically significant at the 0.001% level.

In pursuit of evidences about the relationship between the studied variables, other alternative models were built. In the following alternative model, it was assumed that all the variables involved could have reciprocal relations with each other. Thus, the problems of endogeneity and reverse causality were mitigated. Therefore, all variables are endogenous.

In models 5 to 8 the method of maximum likelihood estimation (MLE) were applied. Tests promoted using two databases, a database with all data, and the other without outliers. The elimination of outliers was performed using the method of Mahalanobis distances. The previous results were confirmed. There were no significant differences in outcomes when using different databases. There were no significant changes in the coefficients, nor changes in the relations.

Next, in models 9 and 10, relationships between governance and value, risk and governance, risk and value, and performance and value were built. Then, in models 11 and 12, only were inserted the relations between governance and risk, governance and value, and risk and value. In model 13, only were included the links between governance and risk and between risk and value. All results obtained with such models ratified the previous outcomes.

Finally the models 14 to 18 were tested, including all control variables, varying the performance variable and restricting the database from five to two years (2005 and 2006). The reduction of the database occurred with the aim of achieving better chi-square indicators for the models.

In resume, the models were identified as follows: a) model 14 - model including all control variables; database from 2002 to 2006; (sqr (*roe*)) as the performance indicator and without a relationship between governance (sqr (*igc*)) and value (log (*mts*)); b) model 15 - model including all control variables; based on data from 2005 and 2006; (sqr (*roe*)) as the performance indicator, including the relationship between governance (sqr (*igc*)) and value (log (*mts*)); c) model 16 - model including all control variables; database from 2002 to 2006; (sqr (*roe*)) as the performance indicator, with a relationship between governance (sqr (*igc*)) and value (log (*mts*)); d) model 17 - model including all control variables; database from 2002 to 2006; (log (*ets*)) as the performance indicator, with a relationship between governance (sqr (*igc*)) and value (log (*mts*)); and e) model 18 - model including all control variables; database of 2005 and 2006; performance indicator (log (*ets*)) with a relationship between governance (sqr (*igc*)) and value (log (*mts*)).

A summary of the relationship between governance, risk, performance and value, explained by the models, can be seen in Table 1.

Summary of the tests that used the structural equations showing the results - loads and covariances - statistically significant. The term W means weight, ie weight of the relationship found, and the term C means coeficient of the relationship indicated. The symbol (***) represents a statistically significant value of 0.001%.

Model	Governance-risk relation	Governance-performance relation
1 (W)	-0,033***	
2 (W)		
3 (W)		+0,096***
4 (W)		
5 (C)	-1,455***	
6 (C)	-0,022***	
7 (C)	+1,426***	
8 (C)	-0,022***	
9 (C)	-0,009***	
10 (C)	-0,009***	
11 (C)	-0,009***	
12 (C)	-0,009***	
13 (C)	-0,898***	
14 (C)	-0,014***	+0,024***
15 (C)	-0,014***	+0,025***
16 (C)	+0,604***	-0,011***
17 (C)	-0,224***	+0,795***
18 (C)	-0,242***	+0,778***
Total	13 (-***) / 2(+***)	5 (+***) / 1 (-***)

Governance-value relation	Risk-value relation	Performance-value relation
	-0,940***	
		-,940***
+0,865***		
	-0,057***	+0,047***

		+0,158***
+0,031***		
	-0,015***	+0,084***
+0,033***		
+0,034***	-0,006***	
	-0,219***	
	-0,667***	
+0,035***	-0,658***	+0,002***
+0,003***	-0,023***	+0,001***
+0,122***	-0,080***	+0,168***
+0,154***	-0,062***	+0,218***
8 (+***)	10 (-***)	7 (+***) / 1(-***)

Table 1: Summary statistics of the coefficients with statistical significance

The results highlighted the relationships and covariances statistically significant, with negative signal, between governance and risk; relations and statistically significant covariances, with negative signals, between risk and value; relationship and statistically significant covariance, with positive signs, between governance and performance; relationships and statistically significant covariances, with positive signs, between performance and value; and statistically significant relationships, with positive signs, between governance and performance.

The relationship between performance and value in the model 4 contradicted expectations. The same occurred in the relationships between governance and performance in the model 16, and between governance and risk in models 7 and 16. In synthesis, only four results that contradict the initial assumptions were found, in the total of 47 outcomes. This set of information represents a high percentage of positive statements (91.5%), in accordance with the hypothesis.

Regarding the control variables, which were included in the models 14 to 18, can be seen, below, in Table 2, the coefficients of its relations with the variable value. In the models mentioned, the control variables were directly related to the value variable.

Models / Relations	14	15	16
Value ↔ sqr (com)	-0,014	-0,014	0,604
Value ↔ log (fixed)	0,024	0,025	-0,011
Value ↔ log (de)	-0,042	-0,042	-0,029
Value ↔log (inv)	0,008	0,010	0,052
Value ↔ log (exp)	-0,013	-0,003	-0,056
Value ↔ log (finl)	-0,152	-0,149	-0,061
Value ↔ log (aopl)	-0,221	-0,217	-0,090
Value ↔ log (bod)	-0,107	-0,125	-0,004
Value ↔ log (liq)	0,110	0,112	0,092
Value ↔ size	-0,183	-0,185	-0,249
Value ↔ tam	0,355	0,368	0,070
Value ↔ pri	-0,022	-0,022	-0,077
Value ↔ lev2nm	-0,005	-0,007	-0,061
Value ↔ adr23	0,186	0,181	0,065
Value ↔ lev2nmadr23	-0,014	-0,014	0,604
Sample	431	431	188
λ^2 (*Chi-square*)	10250	10250	4935
Degrees of freedom	185	184	184
Log Llikelihood			
Number of parameters			
p-value	0,000	0,000	0,000

17	18
-0,224	-0,242
0,795	0,778
-0,064	-0,038
0,015	0,047
-0,040	-0,027
-0,052	-0,057
-0,030	-0,005
0,017	0,007
0,096	0,075
-0,199	-0,229
-0,002	-0,015
-0,067	-0,083
-0,003	-0,011
0,115	0,114
-0,224	-0,242
431	188
293,21	-294,52
26	26

Tabel 2: Summary of the coeficients of the models 14 to 18. Coefficient results for the models 14 to 18. The coefficients represents the covariance between tha control variables and the value variable. The system doesn´t explicit the statistical significance levels of the relations.

5 – Conclusions

The main contribution of this paper is to understand how governance affects the value of companies. Governance can impact only in the risk or only in the performance, or in both. Maybe governance can impact directly in the value without showing respect to the mediating variables of risk and performance. However, it was possible to verify that there is a direct relationship between governance and value. Direct impacts from governance in risk and in performance were also observed.

Another contribution of this paper is to investigate the relationships between governance and risk as Drobetz (2003), Chen et al. (2004), Ashbaugh et al. (2004), and Derwall Verwijmeren (2007) did, among others.

Evidences obtained provided strong support to infer that companies with better corporate governance have lower risk perception in the market, and this is reflected in the cost of capital of companies. The results are in complete agreement with those reported by Ashbaugh et al. (2004), who found direct relationship between the change in governance indicator and the decrease in the implicit cost of capital. The results are also in line with the studies of Chen et al. (2004), in which the authors found that best practices were related to lower costs of equity and capital.

Outcomes are also in agreement with the evidences showed by Derwall e Verwijmeren (2007).

This confirms the efficiency that investors and other market institutions have had over the last few years, to promote differentiation between companies with best governance practices. It was observed that companies with better governance have lower capital costs and better judgments of their risk by the market. Thus, evidences were found that made possible to infer that governance affects the value of companies because it is inversely related to risk and hence to the cost of capital of firms.

The results involving models 1 to 4 (considering governance as an exogenous variable) and models 5 to 18 (considering governance as endogenous variable), confirm the relationship between higher levels of governance and lower risk.

The structural equations also allowed to visualize the negative relation between risk and value of statistical significance, according to model 2 (considering governance as an exogenous variable), or as models 6, 9, 11, 13, 14, 15, 16, 17 and 18, in which governance was an endogenous variable.

Regarding the relationship involving governance and performance, it can be infered, from the results, that better governance is associated with higher margins (log (*ets*)) and lower profitability (sqr (*roe*)). Klaper and Love (2002) and Chong and Lopez-de-Silanes (2006) also found a positive relation between these variables, which can only be found in this research, in the change in the indicator of governance index and profitability (sqr (*roe*)).

About governance and value, it was found that governance is positively associated with higher values (log (mts) and log (mtbv)), and these results are all in line with those obtained by Bai et al. (2002), Klapper and Love (2002), Beiner et al. (2004), Gompers et al. (2003), Brown and Caylor (2004), Leal and Silva (2005), Renders and Gaeremynck (2006) and Black et al. (2006).

Large corporations generally have higher margins because they have market power to impose its trading conditions. On the other hand, they have the ability to offer greater benefits for the placement of their products and thereby increase its market share, allowing them to obtain higher margins in a virtuous cycle. Large firms also have higher market value, according to the results reported by Durnev and Kim (2005), Black et al. (2006), and Leal and Silva (2005). Because they have large volumes of resources to invest, they have lower marginal capacity to optimize the returns, if they are compared to companies with fewer assets, which may be at greater risk, but can achieve better returns on their projects.

It seems that companies with more assets, which, as evidence from the selected sample, have lower profitability, increase market value through the falling costs of the raising funds. This allows them to increase their profits and assets, but the speed with which this phenomenon occurs is dictated by the operating profitability or by the return on invested capital, which are lower in large corporations than in smaller ones. By improving their governance practices, small firms also reduce their cost of capital. However, they increase more rapidly their market value, compared with companies that have greater assets, because they have higher rates of return. This makes possible to infer that the effects of the improvement in governance practices are felt most strongly in smaller companies than in the larger ones. The results of models 3, 14, 15, 17 and 18 show significant and direct relationships between governance and performance, when the variable used was log (*ets*). Models 3 (tested with sqr (*roe*)) and model 16, show negative and significant relationships when the variable of performance used was sqr (*roe*).

On average, and in most companies, it appears that variations in performance, value and cost of capital are not as fast as the changes in the level of the quality of governance, as mentioned in Claessens et al. (2002). However, the perception of lower risk, better control, and higher performance, are associated with the improvement of governance practices even if the existence of reciprocal effects were admited. Finally, better governance and greater market values of companies are associated, even assuming that there is endogeneity in the relationship between governance, performance, risk and value.

The results obtained in models 5, 8, 10, 11, 15, 16, 17 and 18 made possible to infer about the existence of positive and statistical significant relation between governance and value, even in the presence of relations involving the mediating variables - risk and performance - as occurs in the some previously mentioned models. This last result is consistent with the conclusion of Bai et al. (2002), obtained for Chinese companies, that investors decide to pay a premium for companies with best governance practices. Thus, it was possible that investors decided to pay more for companies with better governance practices, although they already know that this variable also increases the value of the companies because of the effect in the risk and in the performance of the organizations.

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RESOURCES SELECTION FOR AGILE/VIRTUAL ENTERPRISES: PART I – MODEL FOR VALUE ANALYSIS INTEGRATION

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Abstract: The markets globalization requires companies to continually invest in innovation, competitiveness and excellence. It is important to create a value culture in companies, through methods such as Value Analysis (VA). Nowadays a product is often produced with contributions from several companies and the concept of Agile/Virtual Enterprises (A/V E) emerged and developed.

In this work, we propose an activity model of VA integration in the resources pre-selection process for A/V E. It was made a literary revision of the existent models of resources selection in A/V E in order to identify the main limitations and gaps of the process and assess the relevance of our work. We built the VA integration activity model and defined the VA stages to incorporate in the pre-selection process.

An integration of a methodology of the type of VA will be able to incorporate surplus value in this process and leads to a better dynamic organizational integration. The VA integration brings a systematic and organized process in order to guarantee a higher value and more confidence in the resources system, contributing to a more sustainable configuration process of the A/V E.

Keywords: Value Analysis, Agile/Virtual Enterprises, Resources Selection, Activity Model

1 - INTRODUCTION

Since many years ago, namely in military campaigns, the resources selection always has assumed basic importance. For example, Sun Tzu [1] in its classic “The Art of War” has already emphasized the relevance of this question. The markets globalization has evolved extremely fast, which originated a bigger attention to the area of the selection of resources. The more dynamic and complex chains provoked a strong increment of the investigation in the resources selection process.

We intend to discuss the potential benefits that the use of VA can add to the A/V E. How can the value generated by an A/V E be measured and estimated? To answer this question we must then relate the A/V E with value models. In addition it is essential to identify and create procedural models and criteria for evaluating the required performance and its consequent impact on organizational change. The performance measures entail benefits for businesses from both economic, technical and social [2]. The VA can play an important role and establish itself as one support tool throughout the A/V E project, which is increasingly emerging as one of the existing paradigms of organizational change.

Currently it is fundamental that companies improve their performance in order to produce products more focused in customer requirements. One method which may contribute to these goals is the VA. The joint application of VA with the paradigms of the A/V E, in which we believe that companies can explore its potential as it happens in the conventional systems, goes towards the future perspective of the A /V E challenges. A/V E, which are under development and optimization involve other factors not considered in conventional companies, and the VA incorporation will bring a new support decision for the A/V E configuration process. These factors are related to the nature of inter-organizations such as: trust, integrity, dynamic reconfiguration and organizational integration of the resources (partners).

2 – RESOURCES SELECTION PROCESS IN A/V E

An extensive literature review has demonstrated that the approaches to the global problem of resources selection in A/V E are very different [3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13]. In this process we intend to deepen the stage of resources pre-selection by integrating the VA, as well as their implications during the final selection of resource systems. This is one of the main limitations in the analysis of the whole global process of resources selection and hence the importance of this work.

Another important aspect for our work has to see with the total absence of references or incorporation of the value concept in the existing models. None of the models found and analyzed in the existent literature incorporates formally the value concept. This indicates that a current paradigm, the value creation, is not treated, analyzed, or integrated in the aspects inherent to the resources selection process.

3 – VALUE ANALYSIS

VA is a well known structured method to increase value and support the selection of the most valuable solution [14]. Throughout recent decades, VA has proven able to reduce costs and ensure quality, while also contributing to the improvement of decision-making and other important organizational tasks.

VA can be defined as an organized and creative methodology that uses a functional approach and aims to increase the value of a product/service [15, 16, 17]. The VA provides a means to link, align and maximize the efficiency of the value chain [18, 19].

It is our belief that the application of VA into the paradigms of A/V E will bring the same contributions to A /V E performance as it has so far done in conventional systems [20, 21, 22]. Furthermore, the incorporation of VA contributes additional support for the A/V E configuration process.

4 – VALUE ANALYSIS INTEGRATION

The performance of the resources pre-selection systems is very important, considering that the integration in the A/V E is a key factor [23]. This performance depends on each type of A/V E project, but the resources pre-selection systems should be prepared to have quality, be quick and cost-attractive to the major requirements. The VA integration should have a positive contribution in this pre-selection in particular:

Evaluate and quantify the parameters associated with the requisites of pre-selection; Evaluate the validation criteria for the resources selection to the A/V E project (validation of algorithms, inputs and solutions).

The overall process of pre-selection with VA integration is represented in figure 1.

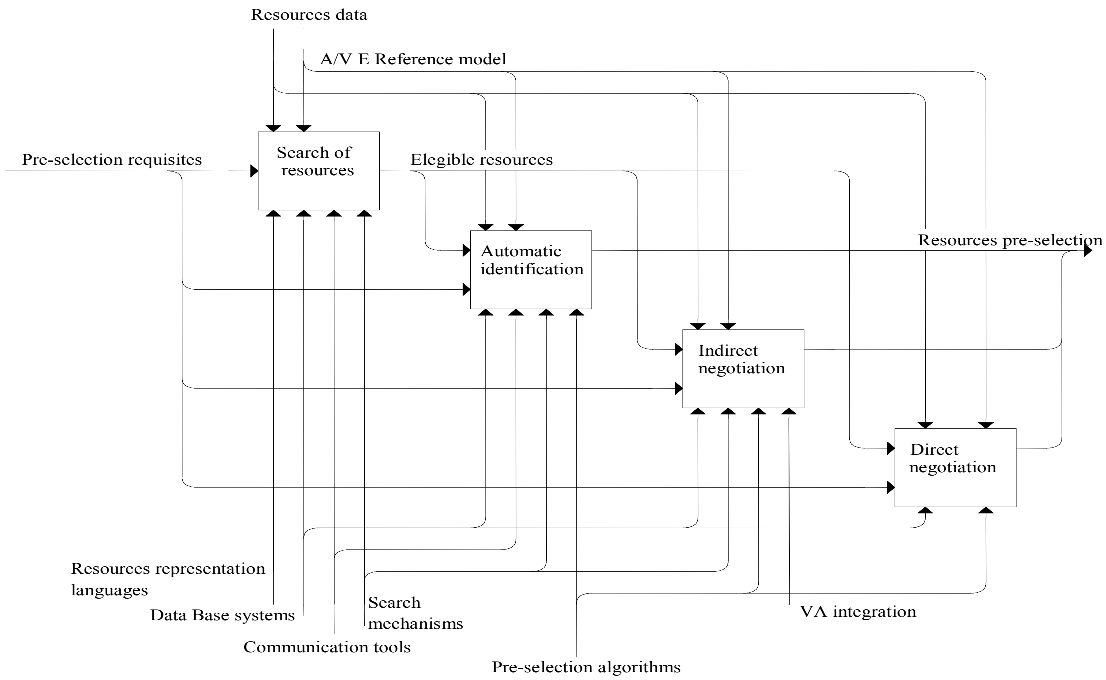

Figure 1 – Representation of Resources Pre-Selection Process with VA Integration

4.1. Adequacy of Indirect Negotiation Phase to the VA Incorporation

In the context of A/V E, indirect negotiation phase is the most used to make the pre-selection of resources, because it is flexible and adjusts to the different requirements of each A/V E, and presents itself as the most appropriate stage to make the VA integration.

In the indirect negotiation phase, are made offers of tasks and their requisites for the eligible pre-selecting resources (bid solicitation) and where the resources candidates involved respond and carry out its proposals for each task (reception). The proposals are then reviewed and accepted/rejected (analysis/evaluation). The main stages of indirect negotiation which we established and defined are: bid solicitation, reception and analysis/evaluation.

4.2 - Pre-Selection Requisites

The pre-selection requisites to consider in our model are associated with the following systems that are grouped into two levels of analysis and treatment. At level 1, the systems of requisites take precedence over the systems of the subsequent level. In the phase of analysis/evaluation of proposals, if the candidate resource does not meet these requisites, it is rejected and the evaluation ends here.

Systems of requisites of level 1: Product/Task; Product/Task Project; Production Process; Production Planning.

Systems of requisites of level 2: Quality System; Financial System; Synergies System.

5 – CONCEPTUAL FRAMEWORK MODEL OF VA INTEGRATION

The main objectives of building the VA integration model into the indirect negotiation phase of resources pre-selection in A/V E appear listed below:

- Integrate the VA at the pre-selection using their techniques and phases;
- Develop the tool of qualitative and quantitative evaluation for resources candidates for pre-selection.

A primary objective to be achieved in the pre-selection process is to undertake a qualitative and quantitative assessment of the candidate resources. This evaluation, using the VA, is not only a final evaluation of the candidate resources quantitative features in this pre-selection, but also a qualitative evaluation inherent to the final selection of the system. As mentioned before, in this indirect negotiation, proposals are analyzed/evaluated and accepted/rejected. This will pass then, by setting minimum acceptable values and their acceptance levels, which should be defined in the algorithm, for the various requirements for pre-selection analysis. For those resource candidates that are considered "fit" given the requisites level of treatment and their objective functions, the VA integration in their overall evaluation (i.e. for all pre-selection requisites), including the incorporation of VA steps, could play an important role and position itself as an extremely useful tool to this pre-selection.

The framework for the VA integration in terms of conceptual architecture is represented in table 1, which shows the VA steps that are incorporated into the indirect negotiation stages as well as their main objectives.

INDIRECT NEGOTIATION STAGES	VALUE ANALYSIS STEPS
BID SOLICITATION	ORIENTATION AND PREPARATION
	FUNCTIONAL ANALYSYS - IDENTIFICATION
	FUNCTIONAL ANALYSYS - CHARACTERIZATION
RECEPTION	INFORMATION SEARCH
ANALYSIS / EVALUATION	FUNCTIONAL ANALYSYS - CHARACTERIZATION
	FUNCTIONAL ANALYSYS - WEIGHTING
	FUNCTIONAL ANALYSYS - EVALUATION

Table 1 – VA Steps in Indirect Negotiation

Next, will be described in more detail this VA integration, explaining what are the objectives and main steps for the process.

6 – ACTIVITY MODEL FOR THE VA INTEGRATION IN INDIRECT NEGOTIATION

The indirect negotiation process with VA integration is represented, in IDEF0 language, in figure 2.

6.1 - Definition of Activities of the Indirect Negotiation Phase

The indirect negotiation process (A0), consists of three main activities (A1 – Ask for Bids, A2 - Reception and A3 - Analysis/Evaluation). In figure 3 appears represented the three main phases of the indirect negotiation process with their VA integration as a common mechanism.

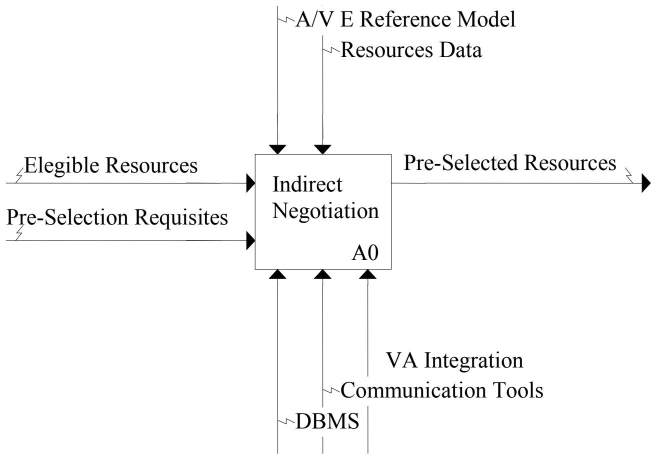

Figure 2 – Representation of indirect negotiation activity with VA integration

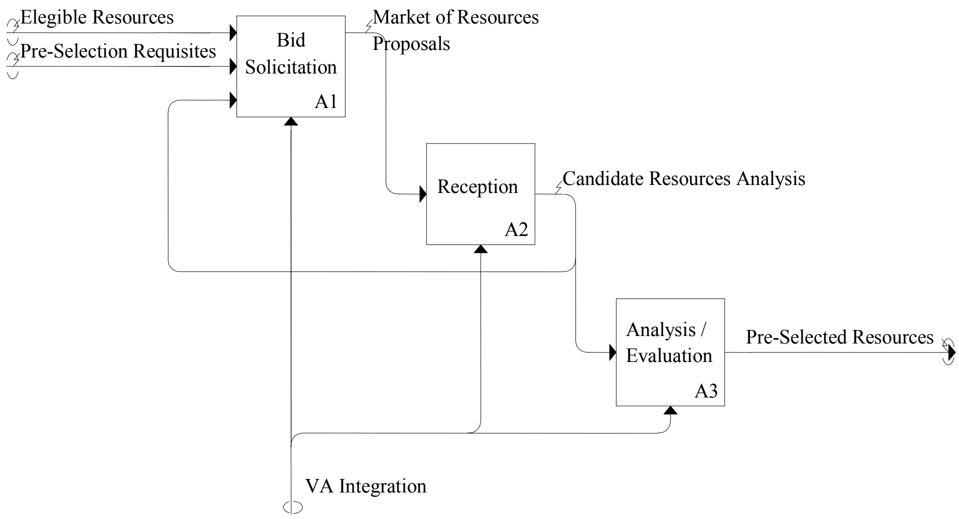

Figure 3 – Representation of indirect negotiation phases with VA integration

6.2 – Bid Solicitation

The Bid Solicitation (A1) corresponds to the initial phase of the indirect negotiation process and includes the activities of Preparation of Bid Solicitation (A11) and Launching Bids (A12), and is represented in figure 4

In this stage is applied the VA step of orientation and preparation and is a prior stage to the launch of bids itself. It consists of a preparatory phase.

Objectives (A11): Provide the best possible conditions to the process.

Main Steps (A11): Define the VA subject matter; Define the main goals and constraints; Schedule of resources (human, physical, temporal, financial, etc.).

Figure 5 represents the VA integration step in the functional analysis (identification and listing) of requisites (A121) and their respective minimum levels (A122), during the activity A12.

Objectives (A12): Identify and list the pre-selection requisites; Define the minimum levels for the pre-selection requisites.

Main Steps (A12): Analyze the product/service using functional analysis methodology.

6.3 - Reception

This is an intermediate stage of the indirect negotiation process and consists of two activities (A21 and A22) i.e. the reception and formatting of proposals and the search for additional information after receiving the proposals and make any necessary adjustments. The reception, with their activities, is represented in figure 6.

Objectives (A21, A22): More and better information; Gain knowledge of the current situation.

Main Steps: Gather all information relevant to the project.

6.4 - Analysis/Evaluation

This is the final phase of the indirect negotiation process, including of five activities and consists in evaluating the objective function (F.O.) of level 1 (A31); if necessary, definition of flexibility degrees for this level (A32); the evaluation of the F.O. of level 2 (A33); the weighting of requisites and systems (A34); and in determining the value (A35). This final phase of indirect negotiating is represented in figure 7.

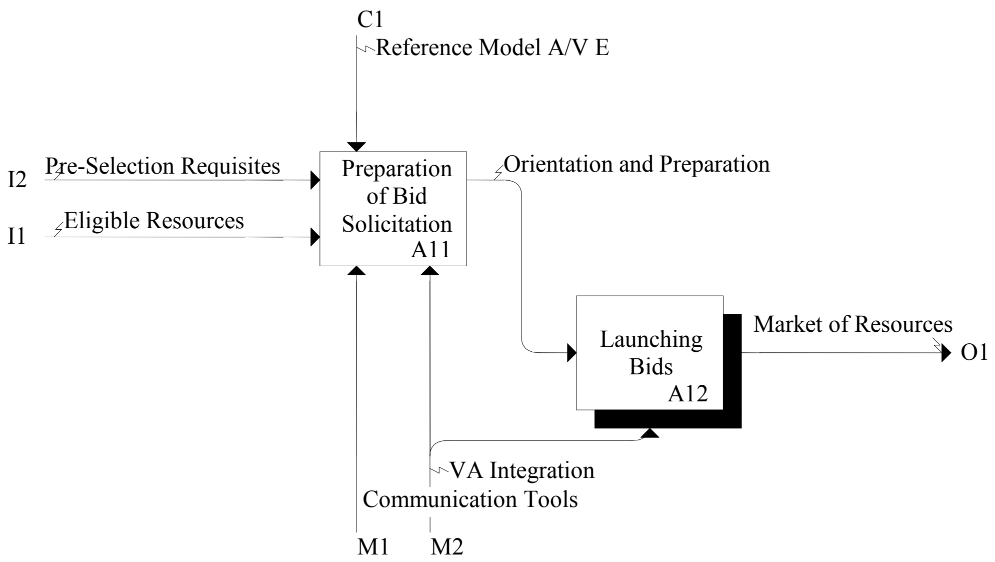

Figure 4 – Representation of Bid Solicitation (A1).

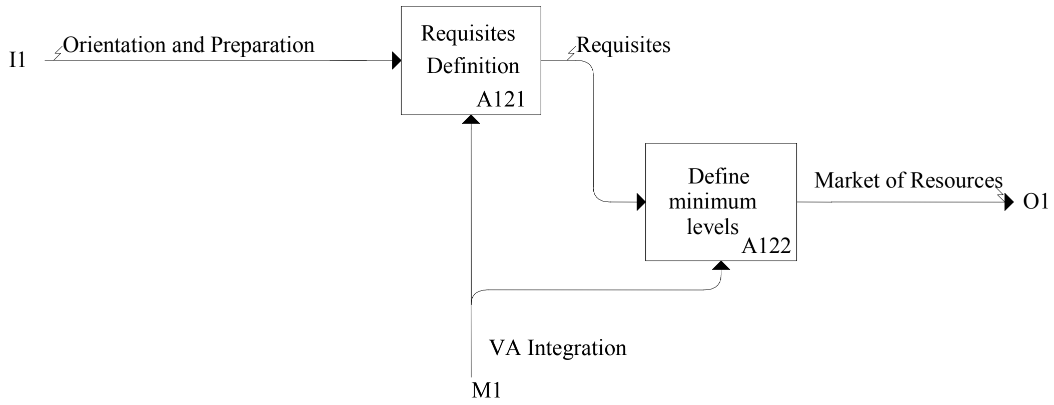

Figure 5 – Representation of Launching Bids (A12).

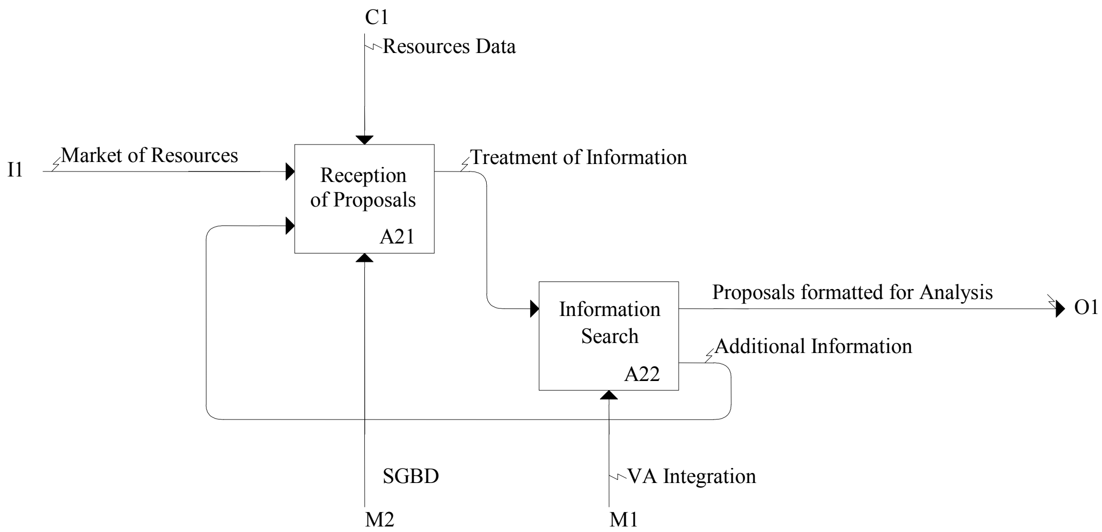

Figure 6 – Representation of Reception (A2).

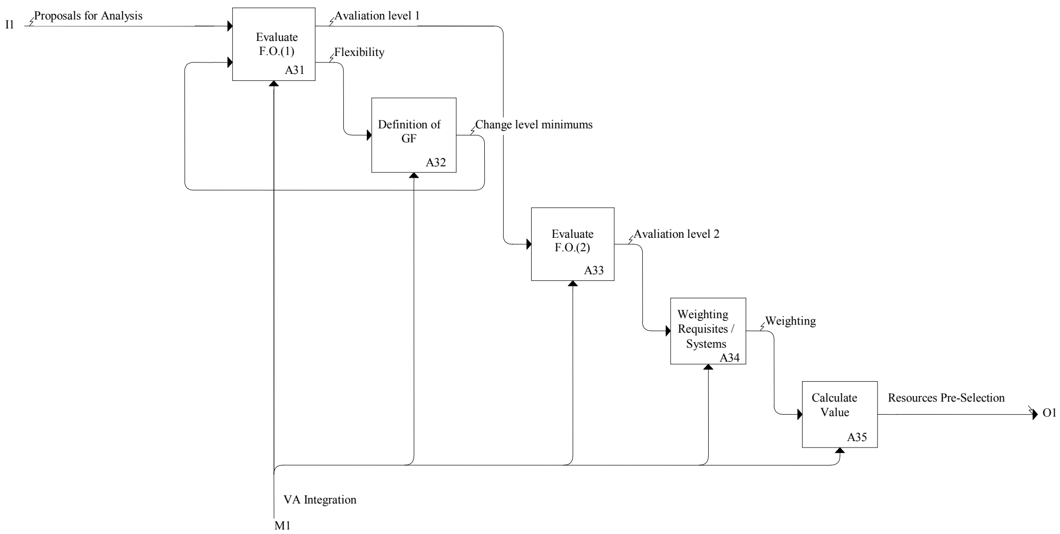

Figure 7 – Representation of Analysis/Evaluation (A13).

At this stage the candidate resources are evaluated to the F.O. of level 1 (A31). The objective function of the level 1 systems are generally of the boolean type.

Objectives (A31): Analysis/Evaluation of the level 1 systems.

Main Steps (A31): Analyze and evaluate the pre-selection requisites of level 1 systems and their objective function.

If for any system of requisites, is not reached the minimum level for any candidate, then we can define degrees of flexibility and reset the minimum values of acceptance for some or all of the requisites considered (A32). If the resources are within the level of acceptance they pass to the level 2 evaluation.

Objectives (A32): Define, if necessary, degrees of flexibility.

Main Steps (A32): Reset the minimum values of acceptance for some or all of the requisites considered.

This activity proceeds with the candidate resources evaluation of the F.O. of level 2 with the evaluation of requisites associated with the level 2 systems: quality, financial and synergies (A33). One type of evaluation that can be used in our model follows a numerical quantification for each system of requisites, with ranges of between 0 and 10, respecting the usual scale used in the VA [20, 24, 25]. The objective is after this quantitative numerical evaluation to weight the system requisites, to then calculate the objective function of the system. This will be a function of maximizing the parameters to consider, in which may be defined, for example, a minimum level of acceptance.

Objectives (A33): Analysis/Evaluation of the level 2 systems;

Main Steps (A33): Analyze and evaluate the pre-selection requisites of level 2 systems.

In this phase (A34) it will be then the weighting of the level 2 requisites and systems in order to evaluate the resources candidates, based on relative importance. We can use the VA weighting matrix or leave open the weights, i.e. using similar weights. It is intended in our model leaves this option open to A/V E promoter, depending on their assumptions and circumstances of each project.

Objectives (A34): Analysis/Evaluation of the level 2 systems; Weighting of the systems and requisites of level 2

Main Steps (A34): Weight the requisites of level 2 on the basis of relative importance within each system; Weight the level 2 systems.

The weighting of requisites and systems can be made on a relative percentage basis, as usual in empirical studies in companies, or using the weighting matrix of the VA. Then we will show the objective functions of level 2 systems, as well as an example of weighting of their associated requisites using the VA weighting matrix [25].

Example: Objective function of the quality system:

Being

r_{ij}, ($_j$ = 1, n), ($_i$ = 1, k): resource candidate $_j$ for the task $_i$

F.S.Q.: objective function of the quality system

ΦSQ_i, ($_i$ = 1 to 5): weighting of the requisites $_i$ of the quality system

PQi_rij; rij, ($_j$ = 1, n), ($_i$ = 1, k) ($_i$ = 1 to 5): parameter of resource candidate $_j$ to task $_i$ to the set of requisites Q_i

$$\mathbf{F.S.Q.\_r_{ij} = (\Phi SQ_1 * PQ_1\_r_{ij} + \Phi SQ_2 * PQ_2\_r_{ij} + \Phi SQ_3 * PQ_3\_r_{ij} + \Phi SQ_4 * PQ_4\_r_{ij} + \Phi SQ_5 * PQ_5\_r_{ij})}$$

That is, in simplified form:

$$\mathbf{F.S.Q.\_r_{ij} = \sum (\Phi SQ_i * PQ_i\_r_{ij})}$$

Example of weighting the requisites of quality system and calculating the objective function

A - quality management systems, B - guarantees; C - service level; D - quality customer focus; E - total quality management;

	B	C	D	E		TOTAL	%	Order Nº
A	B1	A1	D3	E1		1	5,3	F4
	B	B2	D2	B1		4	21,0	F2
		C	D3	E2		0	0	F5
			D	D3		11	57,9	F1
				E		3	15,8	F3
						= 19	= 100	

Figure 8 – Example of the quality system requisites weighting

F.S.Q. = (0,579 * PQ_1_r_{ij} + 0,210 * PQ_2_r_{ij} + 0,158 * PQ_3_r_{ij} + 0,053 * PQ_4_r_{ij} + 0 * PQ_5_r_{ij})

Finally we will determine the overall value of the resources candidates (A35) in order to prioritize/rank the candidate resources by implementing all the objective functions of level 2.

QUALITY SYSTEM: F.S.Q._r_{ij} = ∑ (ΦSQ_i * PQ_i_r_{ij})

FINANCIAL SYSTEM: F.S.F._r_{ij} = ∑ (ΦSF_i * PF_i_r_{ij})

SYNERGIES SYSTEM: F.S.S._r_{ij} = ∑ (ΦSS_i * PS_i_r_{ij})

The evaluation of the candidate resources may be made initially, system by system, pre-selecting those who obtain a value above the minimum level of acceptance for this system (e.g. positive value) or a higher value for its objective function. This evaluation will then be carried out globally by determining the value of the resources candidates for the overall value objective function.

The value objective function (FV) will be:

FV = ∑ ((ΦSQ_i * PQ_i_r_{ij}) + (ΦSF_i * PFi_r_{ij}) + (ΦSS_i * PS_i_r_{ij}))

Objectives (A35): Determine the overall value of the candidate resources.

Main Steps (A35): Calculate the overall objective function (FV) of the candidate resources.

7 – CONCLUSIONS

In the literature review we found a full range of methods and techniques used in the selection of resources. It is noteworthy that we found no explicit and formal models that approached the pre-selection process in a detailed and systematic way. We identified the gaps and limitations in this area and assessed the relevance of the development of our work. It is also to highlight the fact that there are no literature references to the VA incorporation in this process. We think that in this area there will be space and relevance for a more deep and efficient investigation that leads to a better integration of the VA in the whole process of the resource selection of an A/VE project. It is our objective the integration of the VA application, where we expect that this application provides an important surplus value for an A/VE project.

We created a model of VA integration, represented in IDEF0 language, which covers all the resources pre-selection and propose an algorithm to apply the model. We define three main phases for pre-selection: bid solicitation, reception and analysis/evaluation. We explain the VA steps to incorporate in the resources pre-selection. We develop new systems (quality system, financial system and synergies system) within the pre-selection, based on literature reviews on the subject.

It was demonstrated the validity of our goals because we verified the type of VA applicability in the selection process and resource integration of A/V E, i.e. we incorporated the VA on the configuration process of A/V E. This involved the creation of a model that incorporated the AV in the activities assigned to the pre-selection of resources. This model is likely to be measured on their performance. We defined the parameters for characterization and performance of the system by the description of its properties/functionalities.

As a final conclusion it can be said that VA integration on the entire process of A/V E configuration, especially in the pre-selection and consequent final selection of the resources system incorporates a whole range of benefits and gains in all this process.

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MODEL EVALUATION FOR THE OUTSOURCING OF CORE BUSINESS PROCESS

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Abstract: Business Process Outsourcing has been growing in importance for organizations in the last two decades. It was initially used mainly in support activities, but over time has evolved into activities closer to the organization core. Despite the experience gathered using this tool, there is evidence that a large number of Business Process Outsourcing initiatives fail to meet the goals. A structured approach to a Business Process Outsourcing initiative is required in order to achieve the benefits that outsourcing as a management tool offers. The number of outsourcing initiative models are scarce and usually don´t address specifically core processes of an organization. The aim is to discuss outsourcing models existent in literature, select one, of which to investigate three case studies comprising three core business processes of three different companies. The results provide a general validation of the selected model and suggestions for model improvement.

Keywords: management, business_process(es), outsourcing, models.

INTRODUCTION

The use of outsourcing by firms is becoming increasingly common. As a management tool through which an organization transfers work, responsibilities and decision power to an external source, it has a strong impact on the structure and functioning of organizations.

It has also emerged in recent years the need for some companies to move away from management models based on a function-oriented structure to a process-oriented structure.

These changes are caused by the present scenario of global competitiveness where factors such as economic globalization, rapidly changing markets, the pressure to increase level of customer service and constant demand to reduce costs are main topics for managers.

Although some outsourcing initiatives have already been approached using structured models, they focus mainly in support processes in areas like information systems, human resources management, financial activities, and others, but not on the core business processes of organizations.

The decision of some organizations to pursue initiatives of outsourcing of core business processes reinforces the need for implementation models in order to avoid mistakes, minimize risks and maximize benefits.

OUTSOURCING

Although the term outsourcing has only recently entered the lexicon of management through IT publications [9], it is true that it has been practiced for centuries in production and logistics.

Despite the extensive literature produced about outsourcing, there is still some confusion concerning the concept. Some definitions relate to the transfer to third parties of activities carried out within the company. Lei and Hitt [16] define outsourcing as the "reliance in external sources for the production of components and other value-added activities". For Power et al. [21], outsourcing is the act of transferring work, responsibilities and decision-making power to an external partner. Greaver [9] defines outsourcing as the "act of transferring some of a company's recurring activities and decision rights to outside providers, as set forth in a contract". In fact, not only are the activities transferred but also the resources that are used for the carrying out of those activities, like people, equipment, technology and other assets. Other authors focus on the transfer of activities outside their core competencies; Gilley and Rasheed [8] conclude that in most studies the definition of outsourcing is so comprehensive that can include any product or service purchased outside the company.

Guilley and Rasheed [8] sought to clarify the definition of outsourcing, considering it as a highly strategic decision of the purchase from a third party, of goods or services previously performed internally, or that could be performed internally by the existing of expertise or capital capacity. Therefore, it isn't considered outsourcing, when the only possibility is to acquire a particular good or service by the company.

Types of Outsourcing

According to Greaver [9] e Power[9][21], outsourcing initiatives can occur at different levels:

individual, functional and process level. The individual outsourcing is the simplest form since it involves the outsourcing of specific positions of the organization. The functional outsourcing typically develops through the traditional functional structure of organizations. It becomes easier to outsource through the company's existing organizational structure, both for ease in describing the activities, the inputs and outputs, and identifying their costs. The process outsourcing involves hiring a service provider for the management of an entire business process, not just isolated activities or functions.

BUSINESS PROCESS MANAGEMENT

To meet the performance requirements that companies face today, new organization models have been presented with a new perspective and a new way of thinking about the organization. One model is the process-oriented organization the interest in which has grown in recent years with the designation of business process management [1].

The definition of Business Process Management isn't clear, since the interest in Business Process Management is the result of the combination of the approaches to processes done by three different fields: quality control, management and IT [11]. The widely incorrect use by practitioners of the term Business Process Management, also contributed to increased misapprehension of the concept.

Hammer proposes a definition of business process that reflects the structured, cross-functional and costumer-focus nature. Hammer considers that a business process is "an organized group of related activities that together create a result that costumer value" [10].

Business processes, when analyzed from the outsourcing perspective are traditionally divided into core processes and non-core processes [2]. The *core competence* concept was introduced by Prahalad e Hamel [22] and has been adapted and transformed. Seddon [23] considers that core processes are defined by the transactions with customers, translating the work flow from the point where the customer makes the request, to the point where the customer's need is fully met. Any other process is a support process, and is intended solely to support the core processes.

Detoro and McCabe [5] identify characteristics that a process must have to qualify as core:

- "usually provides outputs for clients";
- "it is critical to customer satisfaction";
- "has a high impact on the objectives of the organization".

BUSINESS PROCESS OUTSOURCING

Business process outsourcing is a combination of two management tools, outsourcing and business process management [12]. It is a management tool that "consists of transferring one or more of the firm’s business processes, such as demand management, enterprise services, operations, and supply management to an external provider, who, in return, owns, provides and manages the processes according to some predefined metrics" [20].

The challenge, which arises from identifying an opportunity for business process outsourcing to the implementation and management, directly or indirectly affects the entire organization. The prospect of creating competitive advantage with unique features of the domestic investments, changes to a scenario where competitive advantage comes through a combination of an investment that comes from within and outside the organization.

Inspite of the spread of business process outsourcing initiatives, many authors support the need for a methodological approach to business process outsourcing initiatives in order to avoid mistakes, minimize risks and maximize results [14][25]. The mediocre results of some outsourcing initiatives, are more likely to be consequence of poor management than the existence of wrong motivation [17][19][21]. Nevertheless, there is a lack of models for outsourcing initiatives.

OUTSOURCING IMPLEMENTATION MODELS

In literature, there are different proposals for a methodological approach. Most models address the initiatives of outsourcing only from the customer's perspective. Many authors focus on only a few parts of the outsourcing initiative. Some address the more strategic decision-making issues, others focus on analyzing risks and benefits, while others address aspects of financial and economic nature, such as cost analysis [7][13][17][18][19][20][24]. Some authors have developed models that address the outsourcing initiative including a broader number of stages [4][6][9][14][21][25].

The model developed by Kumar et al. [14], illustrated in Figure 1, consists of five stages:

- Strategy and initiation - the company develops its strategic plan to evaluate the possibility of any outsourcing.
- Analysis of business - the team conducts an analysis and identification of the processes to outsource.
- RFP and Vendor Selection - the team develops the contract specifications and performs the supplier selection.
- Execution and Implementation - the work is transferred from de company to the supplier. During this phase, a strict monitoring of the supplier is required.
- Completion or termination - the company and the supplier review the contract and decide on its completion or termination.

Source: Kumar *et al.[*14]

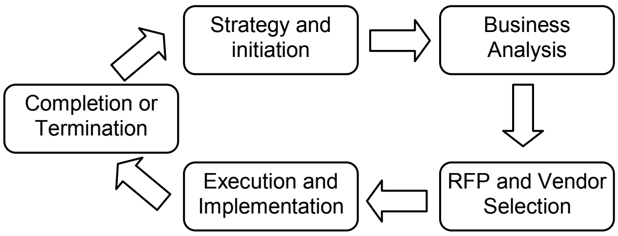


Fig. 1. Kumar *et al.* outsourcing model.

Zhu et al. [25] present a four stages model:

- Planning - the company prepares the business plan for the initiative, identifying actual and foreseeable costs and the feasibility of the outsourcing initiative.
- Development - the business relationship with the supplier is defined, the contract is signed, the impact of the initiative on the workers is studied, the plan for separation of current employees is developed, the plan for the major events of the initiative is prepared and the communication plan is developed.
- Implementation - the transition plan is created, the transition of the business process is accomplished.
- Evaluating - assessment of the outsourcing initiative results.

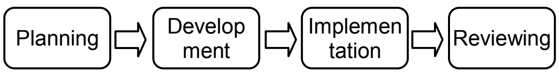


Fig. 2. Zhu *et al.*. outsourcing model

Other authors propose different models. Greaver [9], proposes a model with seven distinct stages, while the model proposed by Corbett [4] is limited to six. However, despite the number of stages and activities that differentiate the model proposals, the most relevant difference is that methodologies such as, for example, Corbett [4] and Zhu et al. [25], consider an outsourcing initiative as one single effort, and others, such as those of Greaver [9], Kumar et al. [14] and Power et al. [21], consider the outsourcing initiative as a continuous work.

The major difference between models that address the outsourcing process as a cycle is not in the number of stages and how different activities are grouped in each stage. In most cases, models consider implementation of an outsourcing initiative as a strategic tool focusing essentially on the same points. The differences between them, lie on issues such as the possibility of parallel development of different stages of the business outsourcing initiative [9] or sequentially, initiating a phase after the completion of the previous one [14][21].

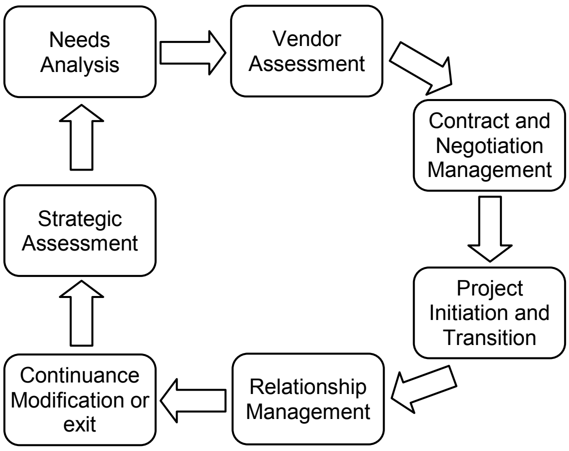
Power et al. [21] discuss business process outsourcing initiative as a process itself thus allowing a systematic view of the details of developing an outsourcing plan, ensure efficiency in managing the outsourcing relationship and improve through practice the efficiency and effectiveness of the initiative.

The model proposed by Power et al. [21], illustrated in Figure 3 consists of the following stages:

- Strategic assessment - the company develops a clear vision of what outsourcing is, how it fits your business strategy and what are the main potential areas for outsourcing.
- Needs analysis - the needs of the organization should be prioritized and defined at the operational level of the outsourcing project or projects they will focus efforts on.
- Vendor assessment - the soliciting, evaluation and selection of the supplier is done in a structured way in order to guide the organization through the selection and contracting activities.
- Contract and negotiation management - the outsourcing contract is prepared, i.e., a legal document that establishes the nature and scope of business.
- Project initiation and transition - the main purpose is making the outsourcing relationship operational, to allow the client the transfer of control to the supplier.
- Relationship management - the goal is to keep the outsourcing relationship up to date,

replacing the direct intervention needed during the transition stage, by supervision of the process.

- Continuance modification or exit strategies - reassessment of the performance of the supplier, the gains obtained by the relationship and how they respond to business needs in order to evaluate the continuance, modification or withdrawl of the outsourcing relationship.



Source: Power et.al [21]

Fig. 3. Power et al. outsourcing model

METHODOLOGY

Most studies in the field of outsourcing result from empirical observation and case studies [3]. Literature is rich in analysis of benefits and risks in addressing strategic issues, but lack background work in respect to tools and guidance in decision support [14]**Erro! A origem da referência não foi encontrada.**.

For the present study three cases were selected. The three selected case studies have some common points: the three companies who took the initiative of outsourcing one of their core processes are logistics service providers; all have the same outsourcer, a company expert in business process outsourcing services in areas of logistics and production; all companies involved have mature organizations with previous experience in outsourcing activities; and all are positioned among the leaders of their activity sectors

The tree cases are explored based on the structure of the method of Power et al. to implement business process outsourcing initiatives. The criteria for choosing this model from other existing possibilities resulted from two features that this model presented: the flexibility and independence of the phases. Being flexible, the model allows the reviewing of the outsourcing decision made, reinforcing the idea that outsourcing is a cyclical process and not a single decision. The non-simultaneous completion of the phases of the model allows them to be conducted independently of the phases that follow. This is important because it prevents reaching preconceived answers at the end of each phase of the model.

As a result, in each case study, the level of fulfilment of each stage of the model is evaluated. Each phase is graded according to the degree of implementation. The grades applied are:

- "Zero" reflects the failure to execute a phase, or the execution of a residual part.
- "Low", translates a phase performed but with serious flaws.
- "Ok" represents an application of the phase with some flaws, but not significant.
- "High" represents a phase in which they fully comply with the model.

The outcome of each outsourcing initiative is rated as success or failure, depending on the continuity or termination of the outsourcing initiative at the end of each cycle.

CORE BUSINESS PROCESSES OUTSOURCING CASE STUDIES

Case 1

The first case study is an outsourcing initiative of a logistics service provider. The services of the logistics service provider include integrated warehousing, inventory control, order preparation, value-added services and distribution. It is active mainly in the logistics sector food and Fast Moving Consumer Goods (FMCG) products. The outsourcing initiative concerns a custom developed cross-docking process for tires distribution. This process is integrated in a logistics operation, to distribute tires from several warehouses and factories of his client, to various points of sale.

Case 2

The second case is in the food distribution sector. The case study is an outsourcing initiative of the repackaging of yogurt cups, carried out under a distribution logistics operation. The company that took the outsourcing initiative is a logistics service provider that is specialized in temperature controlled logistics. The process consists in the conversion of the external packaging of yogurt cups for promotional proposes.

Case 3

The third case study involves a publications distribution company. The company provides a service that includes warehousing, order assembly, delivery, return processing and reverse logistics, of a variety of products including magazines, books and other general merchandise. The outsourcing initiative involved the return processing and reverse logistics process.

Results

Table 1 presents the results of the analysis of the cases in synthesized form.

Table 1 - Summary the cases analysis

Stages	Case 1	Case 2	Case 3
1ª – Strategic assessment	✓✓	X	✓✓✓
2ª – Needs analysis	✓	✓✓	✓
3ª – Vendor assessment	✓✓✓	✓	✓✓✓
4ª – Contract and negotiation management	X	✓✓✓	✓
5ª – Project initiation and transition	✓✓✓	✓✓✓	✓✓✓
6ª – Relationship management	✓✓	✓✓✓	✓✓
7ª – Continuance and modification or exit strategies	X	X	✓✓
Result	**Failure**	**Success**	**Success**

Legend: ✓✓✓- High; ✓✓ - Ok; ✓- Low; X – Zero.

The first point to emphasize the analysis of the three cases is complete fulfilment of the fifth phase, beginning of the transition process. There was a strong perception in all companies of the importance of the transition process. As this is a critical stage at operational level, and therefore with immediate measurable impact on failure, unlike previous phases, planning and executing the transition is done with the utmost care and commitment by the companies. There is no saving of any effort or resources, either from customers or from suppliers.

Another point in common, which is partly the result of proper implementation of the previous phase, is managing the relationship. However this phase is very dependent on the correct description of processes taking place in the second and fourth phase, and the existence of procedures for identifying the need of process modification.

At this stage of relationship management, and given the importance of core processes for companies, there was always availability to find solutions to problems that arose, although the expected results weren't always achieved.

It was also observed that the strategic assessment of the role of outsourcing for business strategy, either was not done at all or, when properly performed, did not lead to the development of the initiative. In the cases analyzed, it was the existence of problems in the processes that led to the search for a solution and therefore the possibility of outsourcing.

Another common aspect to all three cases was the formation of non-multidisciplinary teams in the assessment of processes' needs. In this second phase, for Case 1 and Case 3 as a result of poor definition of the processes to outsource, management indicators and responsibilities of stakeholders, led to conflicts between companies that could have been avoided, saving a lot of effort that was spent finding a solution to them. Having a firmly consolidated basis to serve as a reference for the entire project development is important to assist both parties in overcoming situations of conflict and identify future process modification needs since it is unlikely that the demands and constraints of a core process are to remain constant over time.

One of the criteria considered when selecting the model was that the model does not allow implementation of parallel steps. It was found in Case 1 that the project was launched operationally without a formal contract, affecting the outcome of the outsourcing initiative.

CONCLUSIONS

Through the use of the model of Power et al. to explore the three case studies, one can conclude that errors in the early stages of the initiative, especially until the completion of the contract, have strong implications in the later stages of the initiative and the ultimate success of it. From the cases examined, the one that resulted in failure was the one that had the poorest performance until the stage of project initiation.

However, the model does not create a clear space for the development of the core processes over time, since it doesn't provide any mechanism that allows both companies to identify a change in business process that justifies the modification of the contract. The sixth stage, relationship management, needs to be improved to allow the core process development over time.

Based on the results obtained from these case studies it is possible to observe that the model of Power et al. applies to an outsourcing initiative of core processes. However there is the need for improvement in the sixth stage of the methodology to allow the development of the core process over time.

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SUSTAINABLE DEVELOPMENT, GOVERNANCE AND CORRUPTION

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Abstract: This paper presents a methodological approach to evaluating the relationship between governance and several variables commonly related to the concept of sustainable development. We explore the theoretical framework linking the level of governance of the countries with their economic performance. Our sample incorporates data from developed and emergent countries, collected at the World Bank and Transparency International, in order to assess the significance of governance impact among countries with distinct degrees of development. Multiple regression analysis with panel data modeling were used. Results show a positive relation between levels of governance and economic development, besides illustration other significant issues.

Keywords: Governance, sustainable development, emergent countries, multiple regressions, panel data models.

1. INTRODUCTION

Development is the main goal to be achieved in modern societies. The achievement of development is a complex phenomenon that needs to be viewed in the broad context of its many dimensions including its economic, financial, social, institutional and environmental dimensions. In addition, development is a process that involves relationships among countries that function in different environments. Development advances to different stages with respect to its different dimensions. Thus, countries occupy different stages of development with respect to the economic, financial, social, institutional and environmental dimensions. The complexity of capturing different stages of development across multiple dimensions of development contributes to the difficulty of understanding the development process. This difficulty is compounded when development is considered from the specific perspective of sustainable development.

In the long term, the policies of developing countries aim to achieve high levels of development across its multi-dimensions. At the institutional level, states are led by groups of elected officials and by appointed administrators. This results in power being derived from the electorate, from the competence of administrators and from the strength of the institutions state.

Credibility and managerial capacity are two attributes that should characterize the leadership of an organization, whether in the private sector or in the public sector. Therefore, managers of a nation and of a private business are comparable in some ways. Both groups need to demonstrate efficiency, reliability and maintenance of formal and informal institutions. In addition, both groups need to show good results at the end of the periods for which they are responsible. Thus, the meeting of voluntary practices to promote efficient management as well as internal and external credibility can be defined as a concept of governance for a country.

One pillar of sustainability for an administration is the diffusion of governance actions to improve performance, to achieve objectives and to deliver service in a society. With respect to governance of a state, one may observe management practices ranging from ethical and responsible actions to unethical and irresponsible actions.

In pursuit of long-term sustainable development, countries, institutions and organizations are adopting efficient practices and taking ethical actions to achieve long-term strategic goals. The qualitative and empirical relationships between national governance and indicators of economic progress have been established. For example, evidences of the relationship between the level of governance in a country and the level of economic growth can be seen in the work of Kaufmann (1997, 2003, 2005 (a) and 2005 (b)), Kaufmann and Kray (2002), Kaufmann *et al*. (1999 (a), 1999 (b)), and La Porta *et al*. (1999).

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Given established relationships, it appears that there is a gap in current knowledge, and that gap motivates this empirical investigation of possible relationships between the level of governance in countries and the levels of technological, social and environmental development in countries. In constructing an appropriated framework for this investigation, the corruption index of Transparency International was used as a proxy for level of governance for countries.

The overarching research question in this study is this. Are levels of governance for countries associated with levels of technological, social and environmental development for a heterogeneous group of countries. Economic and financial performance variables were used to control the results.

In the second section of this paper, a theoretical framework is developed to aid in defining the concept of governance for countries. In addition, a base is conceptualized for sustainable development, and that base consists of economic, financial, technological, social, and environmental dimensions. With respect to these dimensions, indicators for operationalizing key variables are defined. In the third section, the methodology is applied that allows for the investigation of possible links between the indicators of governance and the indicators of sustainable development. In the fourth section, results are presented. In addition, in the fifth section, results are analyzed and conclusions are stated.

2. THEORETICAL REVIEW

2.1 Governance of the countries

The current global business environment points to the growing importance of governance. Concern for ethics concerns, opposition to corruption and the implementation of best governance practices are examples of the growing relevance of governance. These practices are in line with those advocated by North (1990). In this context, the process of globalization has amplified the network of links among economic, political, institutional, social, cultural, and environmental factors that operate within, between and among countries.

Barro (1996) reported that empirical research with data for 100 countries between 1960 and 1990 showed that growth in gross domestic product (GDP) is enhanced by education, improved life expectancy, less government consumption, maintenance of legal rules, low inflation, and expanded international trade. In addition, Barro (1996) showed that improving the quality of living standards decisively affects the choice for democracy.

In the global business world, there is no way to dissociate actions to strengthen ethics and to improve governance from actions to curb corruption. This observation is equally valid for for-profit companies as well as for non-governmental organizations (NGOs) and for governments. Thus, improvement in governance practices becomes a priority for the leaders of a state who wants to improve performance to increase access to the global business community and to secure the resources such access provide. In such an environment, there should be a strong relationship between the level of governance of countries and the level of long-term sustainable development of countries.

Regarding the measurement of the level of national governance, Bradhan (1997) noted that at the time of his research, there were no suitable indicators. Since 1995, the organization, Transparency International (T.I.) has produced a corruption perception index (CPI) that measures the levels of corruption among countries. This CPI is constructed from data collected from executives who participate in events sponsored by the World Economic Forum. These executives evaluate the practices of the governments in their countries of origin. The result of these evaluations are compiled by Transparency International and presented on its website. The final index is the result of a combination of these indicators.

This CPI ranges from 0 to 10 points, where the value 0 (zero) indicates the absence of governance practices and the value of ten (10) indicates the highest level of such practices. In relation to this indicator, its endogeneity seems to be its main limitation. From the way this index is designed, it appears to capture more than mere perceptions of corruptions. Thus, this index is used as the indicator of the dependent variable, level of governance of countries.

The corrupt act that was seen as a moral hazard in the past has become increasingly relevant because of the costs it imposes on social, economic, institutional development. From that perspective, the ways to reduce the incidence of corruption cases can be: a) to adopt legislation contrary to the practices of illicit persuasion; and b) to implement good governance rules and codes of best compliance in the organizational structure of the countries.

With genuine support, governance practices can have a significant impact on solving the problems of corruption. According to La Porta *et al*. (1999), such practices are grounded in a) the fairness of the treatment for individuals, organizations, and institutions, b) the transparency of actions by agents, entrepreneurs and regulatory boards; c) the assumption of responsibility for accepting tasks and achieving goals, and d) the respect for laws, rules and standards of conduct that are accepted by society.

2.2 Governance and sustainable development

North (1990) defined economic history as the story of a succession of economies that failed to produce a set of rules and enforcements that could lead society to a sustainable long-term growth. Thus, we believe that North (1990) suggested the prospect of a conceptual relationship between the level of governance of countries and the level of sustainable growth. According to North (1990), effective institutions provide a basic framework that allows for the reduction of uncertainty in trade relations. Thus, along with technology, this institutional framework influences the costs of exchange activities, the profitability of exchange activities and the very viability of economic activities. For North (1990), the keys to economic efficiency are the existence of efficient mechanisms to ensure property rights and to provide for quality managements in these states. Thus, North (1990) related the quality of institutions to the advance of development.

Bradhan (1997) investigated the relationship between corruption and economic development. This work showed that corruption can be manifested in different ways in various societies to undermine other dimensions of economic development. Bradhan (1997), viewed the level of corruption as directly affecting the level of efficiency in an economy. As a successful example of change, Bradhan (1997) referred to the case of Singapore, a country that entered into a cycle of positive increases in development that were associated with a dramatic drop in the level of corruption in the country.

Reinforcing North`s view on governance and property rights, Gradstein (2003) emphasized that the main motivation for state intervention in the economy should be to secure property rights. Gradstein (2003) identified a relationship between a high capacity for enforcement of property rights and positive economic performance in states. Conversely, Gradstein (2003) argued that a low level of governance can affect the ability of states to enforce contracts, and such lack of legal performance would be associated with poor economic and financial results. Barro (1996) reinforced Gradstein`s argument by stressing that governance, when defined as the maintenance of legal rules, is linked to economic growth.

Given prior research, it appears there is a need to investigate the nature of the relationship between governance and economic development. Tiryaki (2008) noted that emergent countries with institutional instability face major obstacles in securing private investments for their energy sectors. This observation is consistent with prior findings, and most probably, it is obvious because electric generation and power distribution projects require significant amounts of investment. By extension of this observation that is specific to energy, it is reasonable to ask if the association between instability in governance and low levels of investment affect all types of investments in a country.

The concept of differing levels investment in societies is reflected by variance in gross capital formation. This capital formation variable is intended to capture part of the potential for infrastructure development that societies may offer to support future investments in social projects that may enable sustainable growth. Research as a percentage of GDP is used as the indicator of the variable, gross capital formation.

Other economic and financial dimensions of sustainable development are included such as: a) the foreign trade; b) the control of countries over the real value currency; and c) the capacity for growth in the private sectors of countries. According to Berg, Dornbush and Fischer (1991) and to Dornbush and Fischer (1991), the respective indicators of these variables are: a) the volume of foreign trade as percentage of GDP; b) the annual rate of inflation; and c) the market value of companies as a percentage of GDP.

Beyond the economic and financial dimensions of development, there are other relevant dimensions. The Brundtland Commission in 1987 in its report to the World Commission on Environment and Development defined sustainable development as growth that meets the needs of the present generation, without compromising the ability of future generations to meet future needs. Thus, according to DETR (1999), sustainable development represents a path forward to the finding a satisfying quality of life in the present and to providing for the same sort of satisfaction in the future. Dernbach (1998) linked sustainable development to the quality of governance of countries. Further Dernbach (1998) argued that the need for sustainable development was pressing because the number of people living in poverty and the environmental degradation was increasing. To investigate a possible association between level of governance and improvement in quality of life, life expectancy is used as an indicator of quality of life.

According to Meadowcroft (2009), to improve the quality of the environment, international agreements operate as instruments of global governance to facilitate cooperation and to promote change. Such agreements enable the reduction of costs and the collective management of problems. However, conflicting cultural visions for advancement and the difficulty in reaching mutual agreements hinder progress at the global level. This context of conflict is aggravated by the recent economic crisis. Thus, Meadowcroft (2009) believed that the task of improving the environment ends up being assigned to each country separately. Accordingly, it is relevant to ask are only countries with good governance able to improve their environments.

O'brien *et al*. (2007) link the state and its governance to the reduction of CO2 emissions because they argued that changing the energy matrix depends on the intervention by the state. In their view, only with subsidies and incentives is it possible to make renewable energy economically and financially competitive. Thus, they emphasized that many economists point to a long and slow transition to renewable energy. They think that the world economy will depend for a long time on energy from fossil fuels such as oil and coal.

To investigate the relationship between the level of governance for countries and environmental variables, the emission of CO2 is used as a indicator of the variable, quality of climate and environment. Thus, it is assumed that level of governance should be negatively correlated with CO2 emissions.

With regard to improving the environment and access to better living conditions, O'brien *et al*. (2007) highlighted the need to rethink and redefine the process of technology transfer. In recent years, the transfer of technology has been slow. Approximately 1.6 billion people do not have access to clean water. In addition, some 2.4 billion people use wood, coal or waste for cooking and for heat. To O'brien *et al*. (2007) governance was the key that would enable to societies to enable advancement through the transfer of technology. The number of Internet users is employed as an indicator of the variable, potential for transfer of technology.

O'brien *et al*. (2007) extended the discussion of technology transfer and showed that only with such transfer, can the poorest countries use their natural resources to generate energy and break the cycle of underdevelopment. Similarly, Barro (1996) noted that the availability of energy is the most important factor in economic growth. Thus, Barro (1996) concluded that every country should strive to be more efficient in its the use of energy to achieve sustainable growth.

Mahmood (2009) and Huang (2008) found that, in poor economies, for a increase of 1% in economic growth to occur, an increase of more than 1% in energy use is needed. In Europe, from 1990 until 2002, according to EEA (2008), there was economic growth of 2.2% relative to growth in energy consumption of 0.5%. These indicators are linked to the pursuit of energy efficiency. In developing countries, Rico and Hidalgo (2008) confirmed an uneven growth of energy intensity in various nations, especially when this indicator was compared to indicators of level of development in countries between 1980 and 2004.

Dernbach and Brown (2009) argued that developed countries have an ethical responsibility to reduce energy consumption by promoting programs of energy conservation and energy efficiency. Thus, it is consistent with their work to search for a relationship between the level governance in countries and the level of improvement with regard to energy management and sustainable development. To investigate such a potential relationship, this study includes two indicators of the energy management variables. The first indicator measures the total energy consumed in terms of kg of oil per dollar of income per capita in one year. The second indicator measures the total amount of energy consumed per dollar of disposable income per capita. in one year. The total expenditure for energy is used as an indicator for the absence of policies for energy management and efficiency. And, the use of electricity is employed as an indicator to measure progress in moving toward less–polluting renewable because most probably the largest supply of power will be derived from the use of renewable energy at the source of the power generation.

3. METHODOLOGY

3.1 Aspects of the research

This research is of an exploratory nature. It seeks to probe the relationships between the level of governance of countries and the stages of economic, financial, technological, social and environmental development. The concepts, the variables and the indicators used in this research are listed in Table 1.

Table 1 - Concepts, variables and indicators

CONCEPT (ATTRIBUTE)	VARIABLES	INDICACTORS OF VARIABLE
Governance of the countries	Corruption	CPI Index as measure by Transparency International
Sustainable Growth – economic dimension	Level of investment in the economy	Levels of Gross Capital Formation as a percentage of the G.D.P. per year of each country
Sustainable Growth – economic dimension	Economic capacity of the state	Levels of G.D.P. growth as a percentage of the G.D.P. per year of each country
Sustainable Growth – economic dimension	Economic capacity of each citizens	Levels of G.N.I. per capita in power purchse parity per year of each country
Sustainable Growth – economic dimension	Insertion in global trade	Levels of the merchandise trade measure as a percentage of the G.D.P. per year of each country
Sustainable Growth – financial dimension	The control and adjustment of public accounts	Levels of annual rates of inflation year of each country
Sustainable Growth – financial dimension	The capacity for growth in the private sectors	Levels of market capitalization by the public held companies as a percentage of G.D.P. per year of each country
Sustainable Growth – environmental dimension	Air pollution	Levels of CO2 emissions *per capita* per year of each country
Sustainable Growth – environmental dimension	Electricity use	Levels of electric power consume *per capita* per year of each country
Sustainable Growth – environmental dimension	Total energy use	Levels of total energy consume *per capita* per year of each country
Sustainable Growth – technological dimension	Access to information and culture	Levels of percentage of the total population that is Internet users per year of each country
Sustainable Growth – social dimension	Life quality	The expectancy of life measured by the number of years for each year of each country

Secondary data were obtained from World Bank and Transparency International for the period, 2000 to 2008. The universe for this study is composed of 228 countries. The focal sample includes a set of 54 countries. To construct this sample, countries were selected that have available more than 70% of the data surveyed in the years under investigation. Table 2 shows the countries that make up the sample.

Table 2 - Countries of the sample

Countries in alphabetical order (1 to 10)	Countries in alphabetical order (11 to 20)	Countries in alphabetical order (21 to 30)
Angola	Czech Rep.	Hungary
Argentina	Denmark	India
Australia	Egypt	Indonesia
Austria	Ecuador	Ireland
Belgium	Finland	Iceland
Brazil	France	Israel
Canada	Georgia	Italy
Chile	Germany	Japan
China	Greece	Malaysia
Colombia	Hong Kong	Morocco

Countries in alphabetical order (31 to 40)	Countries in alphabetical order (41 to 50)	Countries in alphabetical order (51 to 54)
Mexico	Portugal	Ukraine
Mozambique	UK	Uruguay
Netherlands	Russia	USA
Nigeria	South Africa	Venezuela
Norway	South Korea	
New Zealand	Spain	
Pakistan	Sweden	
Paraguay	Switzerland	
Peru	Thailand	
Poland	Turkey	

3.2 Hypothesis

The hypotheses to be tested in this research include the following:

H1: There is a negative relationship (-) between level of governance of countries and CO2 emissions. Countries with better governance, as reflected in the management of structures and institutions, are expected to have the capacity to improve production processes and to align production with standards of sustainable development.

H2: There is a positive relationship (+) between level of governance of countries and number of Internet users. Countries with better governance are expected to enable their citizens to have access to technology.

H3: There is a positive relationship (+) between level of governance of countries and levels of life expectancy. Countries with better governance are expected to provide a good quality of life for their citizens and this quality of life is expected to be reflected in the life expectancy of citizens.

H4: There is a negative relationship (-) between level of governance of countries and energy consumption. Countries with better governance are expected to develop policies to reduce per capita consumption of energy.

H5: There is a positive relationship (+) between level of governance of countries and use of electricity. Countries with better governance are expected to use of renewable energy sources.

H6: There is a positive relationship (+) between level of governance of countries and gross capital formation. Countries with better governance are expected to secure investment in their economies.

H7: There is a positive relationship (+) between level of governance of countries and growth in GDP. Countries with better governance are expected to show growth in GDP.

H8: There is a positive relationship (+) between level of governance of countries and per capita income. Countries with better governance are expected to enable citizens to obtain wealth.

H9: There is a positive relationship (+) between level of governance of countries and the market value of companies that are traded publicly on stock exchanges. Countries with better governance are expected to have the capacity to attract foreign investment and such investment is expected to generate value for publicly traded companies.

H10: There is a positive relationship (+) between level of governance of countries and volume of foreign trade. Countries with better governance are expected to foster trade with other countries to meet the needs of citizens and to expand economic activity to enable further development by making products and services that add value to businesses accessible inside the country.

H11: There is a negative relationship (-) between level of governance of countries and inflation. Countries with better governance are expected to administer public resources in a sound way ant thus to have low rates of inflation.

3.3 Models used in this research

To determine if there are relationships between the level of governance of countries and other economic, social and environmental variables, the method of linear regressions with panel data was employed as shown below:

$$CPI = \beta_0 + \beta_1 * CO_2 + \beta_2 * eletpowcons + \beta_3 * enerusers + \beta_4 * gcf + \beta_5 * lg\,(gdpgrowth) + \beta_6 * lg\,(gnipcppp) + \beta_7 * inf + \beta_8 * intusers + \beta_9 * lifeexp + \beta_{10} * markcap + \beta_{11} * merchtrade + \xi$$

Where:

$CPI = level\ of\ governance\ of\ each\ country;$

$\beta_0 = linear\ coeficient\ of\ the\ linear\ regression;$

$\beta_i = coefficients\ of\ the\ variables,\ where\ 11 \le i \le 1;$

$CO_2 = CO2\ emissions\ (tons.\ per\ capita);$

$eletpowcons = eletric\ power\ consumption\ (KWh\ per\ capita);$

$eneruse = use\ of\ energy\ (Kg\ of\ oil\ per\ capita);$

$gcf = gross\ capital\ formation\ (billions\ of\ dólares);$

$gdpgrowth = anual\ internal\ product\ growth\ (\%);$

$gnipcppp = income\ per\ capita \begin{pmatrix} parity\ purchase\ power \\ - US\ dollars\ per\ year \end{pmatrix};$

$inf = annual\ inflation\ rate\ (\%);$

$intusers = internet\ users\ (percentage);$

$lifeexp = life\ expectancy\ (measured\ in\ years);$

$markcap = market\ value\ of\ public\ companies\ traded\ in\ stock\ exchanges\ (billions\ of\ US\ dollars);$

$merchtrade = merchandise\ trades\ (billions\ of\ US\ dollars);$

$\xi = error\ term\ of\ the\ equation;$

Linear regressions were run and tests of robustness were made using structural equations. The equations were constructed from a concern that the level of governance of countries could have an endogenous relationship with all the other variables included in the study.

The schematic summary of the equations is

$$CO_2 = f(CPI)$$
$$eletpowcons = f(CPI)$$
$$gcf = f(CPI)$$
$$enerusers = f(CPI)$$
$$gcf = f(CPI)$$
$$lggdpgrowth = f(CPI)$$
$$lggnipcppp = f(CPI)$$
$$inf = f(CPI)$$
$$intusers = f(CPI)$$
$$lifeexp = f(CPI)$$
$$markcap = f(CPI)$$
$$merchtrade = f(CPI)$$

4. RESULTS

To utilize linear regression using ordinary least squares (OLS), it is first necessary to apply tests of normality and of heteroscedasticity. The Jarque-Bera (J-B) test was used to test the normality of the variables. Only the variables for internal product growth and for per capita income needed to be transformed, and the logarithmic function was used to transform them. The Lilefors, Cramer-von-Mises, Watson, Anderson-Darling and Maximum Likelihood tests were then applied to conform the tests of normality. Subsequently, equality test of the variances were run, using the Bartlet, Levene and the Brown-Forsythe methods. After constructing the panel data with all the necessary adjustments, the OLS method of linear regression was employed. The results of J-B normality and homoscedasticity tests are reported in Table 3.

Table 3 - Data were presented with their p-values. The symbols * and ** identify which tests of homoscedasticity were performed with fewer degrees of freedom, respectively 5 and 2 degrees.

	Average	J-B	Bartlet	Levene	Brown-Forsythe
CPI* (n = 486)	5,4198	42,9871 (0,0000)	29,8393 (0,0000)	11,7717 (0,0000)	10,1098 (0,0000)
CO2 (357)	6,2325	38,6954 (0,0000)	N.A.	12,9702 (0,0000)	6,9702 (0,0000)
lifeexp (n = 442)	71,7149	2166,614 (0,0000)	228,0713 (0,0000)	36,0632 (0,0000)	33,8545 (0,0000)
intusers (n = 472)	31,7911	41,9760 (0,0000)	11,6868 (0,0198)	3,3275 (0,0106)	3,0253 (0,0176)
eletpowcons (485)	5532,7010	968,7987 (0,0000)	7,9021 (0,0481)	7,8477 (0,0000)	5,7297 (0,0000)
enerusers (n = 411)	2969,8613	227,8709 (0,0000)	11,9275 (0,0076)	10,2207 (0,0000)	11,7402 (0,0000)
gcf (n = 456)	22,2713	232,5915 (0,0000)	28,6040 (0,0000)	9,6094 (0,0000)	6,5059 (0,0000)
lggdpgrowth (n = 477)	0,57519	6,1962 (0,0451)	35,1094 (0,0000)	6,8157 (0,0000)	6,1925 (0,0004)
lggnipcppp (n = 485)	4,0353	42,2967 (0,0000)	101,9964 (0,0000)	33,6972 (0,0000)	20,0150 (0,0000)
inf (n = 482)	8,1511	1307413 (0,0000)	39,2343 (0,0000)	3,9016 (0,0090)	2,0345 (0,1082)
markcap** (n = 455)	71,2462	2999,119 (0,0000)	4,8850 (0,0869)	3,0894 (0,0464)	2,7151 (0,0672)
merchtrade (n = 486)	65,4856	3304,807 (0,0000)	23,1126 (0,0000)	11,2616 (0,0000)	8,0419 (0,0000)

After the adjustments were made, the VIF test was used to determine if there was evidence of multicollinearity among the variables in the sample. The results for all variables, in all models were less than 2.0, indicating the absence of multicollinearity for the data tested. After performing all these tests and applying the method of linear regression, results were obtained that are reported in Table 4.

Table 4 - Results of linear regression with panel data with their respective p-values. The symbols *, **, ***, **** indicate, respectively, values statistical significant at 10%, 5%, 1% and 0.1%.

Variável dependente: CPI	Variáveis independentes
CO_2	- 0,0489* (0,0551)
eletpowcons	0,0001**** (0,0000)
enerusers	- 0,0001 (0,1681)
gcf	- 0,0305* (0,0970)
lggdpgrowth	- 0,6238** (0,0443)
lggnipcppp	3,1690**** (0,0000)
Inf	- 0,0431**** (0,0004)
intusers	0,0232**** (0,0000)
Lifeexp	-0,0178 (0,1073)
markcap	0,0054**** (0,0001)
merchtrade	- 0,0022 (0,1781)
C	- 5,9000**** (0,0000)
Number of observations	275
R^2	0,8210
R^2 adjusted	0,8236
DW	2,0743
Log Likelihood	- 408,3868

Subsequently, residuals tests of normality and homoscedasticity were conducted. The results are reported in Table 5.

Table 5 - Results of linear regression with panel data with their respective p-values in parentheses. The symbols *, **, ***, **** indicate, respectively, values statistically significant at 10%, 5%, 1% and 0.1%.

Residuals tests	Normality (J-B)	Homocedasticity (Bartlet)
Dependent variable (CPI)	4,6000 (0,1002)	17,1606 (0,0007)

Homocedasticity (Levene)	Homocedasticity (Brown-Forsythe)
5,7606 (0,0008)	5,7001 (0,0008)

The Wald test was used to check for the existence of nil values for the coefficients. This hypothesis was rejected at a significance level of 0.01%.

4.1 Robustness Test

To test for the robustness of the results, a model of structural equations was applied. The results are reported in Table 6, and show the analysis of data from the period 2000 to 2008.

Table 6 - Results of linear regression with panel data with their respective p-values in parentheses. The symbols *, **, ***, **** indicate values statistically significant at 10%, 5%, 1% and 0.1% respectively.

Model of structural equations	Factors	Covariances (p-values)
CPI- CO_2	- 0,045	- 0,396 (0,158)
CPI-eletpowcons	0,183	2034,486**** (0,000)
CPI-enerusers	0,043	194,289 (0,148)
CPI-gcf	- 0,047	- 0,494 (0,101)
CPI-lggdpgrowth	- 0,054	- 3,356***** (0,000)
CPI-gnipcppp	0,702	17752,700**** (0,000)
CPI-inf	- 0,083	- 3,492* (0,003)
CPI-intusers	0,270	13,497**** (0,000)
CPI-lifeexp	0,062	1,604** (0,033)
CPI-markcap	0,168	22,736**** (0,000)
CPI-merchtrade	- 0,045	- 4,184 (0,103)
CMIN	2910,24 (0,000)	
RMSEA	0,324 (0,000)	
df	56	
Number of observations	486	

5. ANALYSIS OF RESULTS AND CONCLUSIONS

The average per capita income of the sample was approximately $ 17,811 (seventeen thousand, eight hundred and eleven U.S. dollars) per year, and average GDP growth was 3.76% per annum in the same period. The governance index averaged of 5.42 and ranged between 5.33 and 5.51, increasing in value over time with an average value in 2008 of 5.47. The data relating to governance indicate improvement in governance is feasible.

Test of hypothesis (H1), that higher levels of governance are associated with lower CO2 emissions, was confirmed. This result is consistent with the findings of O'Brien et al. (2007) and of Brown and Dernbach (2009). The robustness this test showed a negative sign, according to the result obtained in the first test, but the statistical significance was 15.8%.

Tests of hypothesis (H2) confirmed the initial expectation that higher levels of governance are associated with a higher number of Internet users, an indicator of technology transfer. The initial result was highly significant statistically and its high significance was confirmed by the robustness test. These results were aligned with the trends indicated by O'Brien et al. (2007) and by Brown and Dernbach (2009).

Tests of hypothesis (H3) did not confirm that higher levels of governance are associated with greater life expectancy. Also, tests of hypothesis (H4) confirmed that higher levels of governance are associated with a higher use of energy, rather than a lower use of energy. This result concerning energy usage was contradictory to the expected result but it was not statistically significant. Accordingly, it is not possible to conclude anything with respect to hypotheses (H3) or (H4).

Tests of hypothesis (H5) confirmed the association between higher levels of governance and greater use of electricity. The results of the first test were high in statistical significance and the second test confirmed the initial hypothesis.

Tests of hypothesis (H6) established a possible link between higher levels of governance and decreasing levels of gross capital formation as a percentage of the GDP rather than a link with increasing levels of gross capital formation as expected. The initial result showed high statistical significance and was contrary to expectations. The robustness test was aligned with the first result. Accordingly, hypothesis (H6) was rejected.

Hypothesis (H7) that higher levels of governance would be associated higher rates of growth in GDP was rejected. Results showed that for the period being investigated, better governance was associated with lower rates of growth of GDP.

It was possible to confirm hypotheses (H8) or (H9) that pertained respectively to the association of higher levels of governance with higher per capita income and with increased market value of publicly traded companies.

Tests of (H10) did not confirm the possibility of an association between higher levels of governance and greater volumes of foreign trade. Finally, tests of (H11) did confirm the expected association between higher levels of governance and lower rates of inflation.

In summary, linear regression with panel data detected with statistical significance that higher levels of governance were associated with the following indicators:

a) lower CO2 emissions (H1),

b) higher number of Internet users (H2) indicating greater access to technologies,

c) increased consumption of electricity (H5),

d) higher levels of per capita income (H8),

e) higher market values of publicly-traded companies (H9) and

f) lower annual rates of inflation (H11).

From the finding that higher levels of governance are associated with lower growth in GDP (H7) one may ask, do countries with substantial assets expend more resources to improve governance but have less opportunity to generate observable returns because of the high volume of funds they manage.

Another important observation was that for the period studied (2000-2008), higher levels of governance were associated with a decreasing volume of gross capital formation (H6), which may be linked to the growth in consumption in developed countries that culminated with the recent economic crisis and financial experience.

It seems that the level of governance on average increased during the period studied, this increase was accompanied by a reduction in CO2 emissions (H1), an increase in access to technologies with expanded access to information and knowledge (H2). Both these finding provide some hope for sustainable growth in poor countries. There is a need for improved production projects that contribute to lower CO2 emissions. Furthermore, countries should pay special attention to the development of secondary markets in securities linked to CO2 emissions. Most countries have a growing demand for energy. Because fossil fuels can be expected to increase in price, there is a need to explore alternative sources of energy.

Finally, higher levels of governance were found to be associated with indicators of public financial management, as evidenced by the growth of income per capita (H8), by increasing market values of publicly traded companies (H9) and by low rates of annual inflation (H11). These results showed some of the possible consequences of better governance practices, in the form of less corruption, as an influence in the governments of various countries. Less corruption is associated with countries that demonstrate development with respect to economic, financial, social, institutional and environmental attributes.

Growth in the level of governance seems to be steady. This growth in level of governance appears to be associated with growth in an infrastructure to support processes to achieve sustainable growth.

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FIBRE-REINFORCED COMPOSITE MATERIALS: AN IMPROVEMENT IN SUSTAINABILITY

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Abstract: The environmental impact of materials (e.g. composites) can be accessed from different perspectives, such as raw materials acquisition, manufacturing processes, packaging and shipping, in-situ installation, indoor air quality, durability and performance, energy saving during use and end-of-use resource recovery. Theoretically, "fully sustainable composites" should employ renewable raw materials of a sustainable origin without harming the environment or depleting any resource, be fabricated with technological processes holding little environmental impact and at the end of the product life cycle, which should be as long as possible, they should be biodegradable or recyclable to be used as input in the fabrication process. The main objective of this work is to present the state-of-the art developments in terms of composite materials characteristics and respective improvements to the conventional materials, design and fabrication considerations and applications. Bio composites, based on natural raw materials, will also be discussed regarding possible applications.

Keywords: Composites, Sustainable products, Environmental Impact.

INTRODUCTION

Sustainability is related to meeting the needs of the present without compromising the ability of future generations to meet their own needs (Definition of the World Business Council for Sustainable Development). Here, the word “sustainability” can relate to the carrying capacity of the ecosystem, and be described with input-output models of energy and resource consumption. Sustainability can also be pictured by a scenario in which the population or industrial demands upon the environment can be met without reducing the capacity of the environment to provide for future generations. Or, as an ecological golden rule for the restorative economy, as it says: “*leave the world better than you found it, take no more than you need, try not to harm life or the environment, make amends if you do*”. Sustainability thus generically means that any business or material must deliver products or services to the customer after careful ecological design that reduces consumption during fabrication, energy use during the whole life cycle, distribution costs, economic concentration, soil erosion, atmospheric pollution, and other forms of environmental damage.

The environmental impact of products (in the present case, composites) is assessed from raw materials acquisition, manufacturing processes, packaging and shipping, in-situ installation, indoor air quality, durability and performance, energy saving during use and end-of-use resource recovery [1, 2]. Thus, conventional fibre-reinforced composites (e.g. carbon or glass fibre reinforced ones) can be considered to have the following advantages over conventional materials:

- *Raw Materials Acquisition*: polymeric matrices can use additives to minimize toxicity, the environmental impact of the raw material acquisition can be minimized by careful extraction processes.
- *Manufacturing Process*: minimization of scrap material generated, press or autoclave used to cure the composites can take advantage of closed-loop water systems, high efficient heating systems (low energy loss).
- *Packaging/Shipping*: minimizes use of packaging, packaging is reusable.
- *In-Situ Installation/Assembly*: composite components provide minimal risk to installers (e.g. lightweight), not requirement of volatile installation materials, absence of installation waste, installation with conventional tools and methods.
- *Indoor Air Quality & Maintenance*: no volatile or other toxic emissions are produced, prevents microbial growth, maintenance/ cleaning with non-toxic cleaning materials and methods.
- *Durability & Performance*: composites last longer without corrosion problems or degradation, even to extreme environmental conditions, such as temperature, wind, rain or humidity (and easy protection to specific

degradation factors by mixing of additives with the matrix).

- *Energy Saving During Use*: the composites main advantage in which regards to sustainability is the excellent strength/stiffness to weight ratio, which allows much lighter components and tremendous energy saving during a long span utilization (e.g. vehicles, aeroplanes or trains).
- *Resource Recovery*: composite materials are recyclable up to some extent, and large efforts are currently being carried out in this field.

Sustainable composites, beyond the above mentioned issues, should provide the minimal possible impact upon the environment. Theoretically, "fully sustainable composites" should employ renewable raw materials of a sustainable origin without harming the environment or depleting any resource, be fabricated with technological processes holding little environmental impact and at the end of the product life cycle, which should be as long as possible, they should be biodegradable or recyclable to be used as input in the fabrication process. In the limit, sustainable composites can be manufactured using as reinforcement renewable fibre crops such as flax, hemp or jute, bound together with an organic or inorganic matrix. Ideally, the matrix will be manufactured from sustainable resources. Such materials are sometimes referred to as "bio composites", "eco composites" or "green" composites. Although the bigger share in the use of composites still goes to artificial and energy consumption processes, a large effort has been made for the use of bio composites [3]. The consideration of vegetal fibres as a renewable raw material is an effective alternative, both economically and environmentally. Traditionally, vegetal fibres are largely employed in the textile industry, paper manufacture, and packaging. In fact, owing to their specific properties added to the ecological factor, vegetal fibres are gaining increased attention in obtaining composite materials. Alternative approaches to sustainability in composites include materials that are readily recyclable.

The main objective of this work is to present the state-of-the art developments in terms of composite materials characteristics and respective improvements to the conventional materials, design and fabrication considerations and applications. Bio composites, based on natural raw materials, will also be discussed regarding possible applications.

BASICS OF COMPOSITE MATERIALS

Composite materials consist of two or more constituents with significantly different physical and/or chemical properties, with the objective of exceeding their limitations when used individually and to combine their competitive characteristics, even though they remain insoluble the macroscopic level. The human being has used natural composites for thousands of years. The oldest example dates back to the Biblical ages, consisting of mud bricks strengthened with vegetal straw for house construction, for the increase of tensile strength of a material that individually only has good compressive strength.

Fibre-Reinforced Plastics (FRP) include the strengthened GFRP (Glass-Fibre Reinforced Plastics), CFRP (Carbon-Fibre Reinforced Plastics) or aramid fibres (Kevlar®) composites, among others, and they are typically used in applications that need high specific strength and stiffness ratios (i.e., values normalized by the weight). This allows reducing the weight of components and structures, comparing with the traditional materials, keeping the necessary strength and stiffness to support the imposed loads. Fig. 1 compares the specific mechanical strength of some structural metals and FRP (VF is the fibre percentile volume).

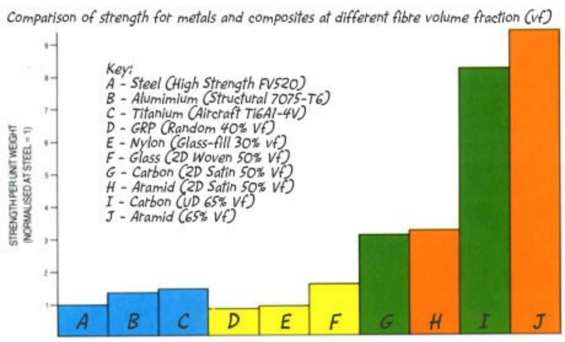

Fig. 1. Comparison between the specific mechanical strength of some structural metals and composites.

In the case of the GFRP (D, E and F), it is possible to match the structural specific strength of high resistance metals, with lower raw material and manufacture costs. In some cases, the excellent resistance to adverse environments (contact with toxic products and moistness) is also an important factor in the selection of these materials. These characteristics are given by an appropriate choice of the matrix material that involves and protects the fibres, or eventually by the use of additives or coatings. The limit of applicability and typical use of these materials are only stopped by their cost (e.g. CFRP and Kevlar® composites), which increases along with their mechanical characteristics. In the end, it is the balance between the cost, performance and importance of the competitive advantage of these materials that allows choosing them to replace materials as steel or aluminium.

FIBRE-REINFORCED COMPOSITES

The developments in FRP were one of the major achievements of the 20th century in which concerns the materials technology. Actually, in the modern society all of us depend on these materials in some aspect of our lives. The FRP includes two categories of constituent materials: the matrix and the reinforcement. The matrix confers the component ductility (capacity to deform plastically) and tenacity (capacity of a material to resist the propagation of a crack under static or fatigue loads), and it promotes the setting and aggregation of the reinforcement fibres in the desired form of the component. It also protects the fibres against external agents as the human touch, corrosion or wear (the reinforcement fibres are extremely fragile). It is the matrix that limits the service temperature of these composites. The reinforcement fibres also enhance the matrix properties by their excellent resistance to tensile and compressive loadings (provided that these are supported by the matrix, which prevents buckling phenomena). This synergy results in superior material properties, not available in the individual constituent materials. The FRP are typically manufactured by the stacking of previously resin impregnated and pre-catalysed plies in the form of unidirectional layers or unidirectional tape, with a unit thickness between 0.125 and 0.25 mm, or by fabric deposition in the mould with subsequent manual resin application. The choice of the stacking sequence, which represents the orientation of the overlapped layers, allows shaping the component strength according to the loading conditions. The reduced thickness of the layers of the resin impregnated layers or FRP fabric supposes components of relatively small thickness (limited to some millimetres). Thus, for three-dimensional structures or with bigger thickness requirements (e.g. to support bending loads), FRP components are typically hollow or with nuclei of another material (foam or honeycomb structures), respectively.

By the careful selection of the reinforcement material, matrix, fabrication process and stacking sequence, it is possible to mould the properties of these materials to fulfil specific requirements for a given application. It is possible, for example, to make a FRP component very strong in a given direction by the alignment of the reinforcement fibres in this same direction, being less resistant in directions where the loads are not so important. It is equally practicable to improve the component characteristics, as the resistance to high temperatures, to chemical products, moistness, wear or tenacity by the adequate choice of the matrix material or through mixing with additives or using coatings. The design flexibility of FRP is another advantage, since these can be moulded in complex forms as surf boards or boat hulls. The majority of FRP fabricated nowadays uses carbon, glass or Kevlar® as reinforcement, and polyester, vinyl ester or epoxy matrices. High performance FRP components as the CFRP or Kevlar® reinforced ones are currently used in diverse applications, such as aeronautical structures or competition sports equipment, in severe environments, being typically constituted by carbon fibres in a polyester or epoxy resin.

FABRICATION TECHNIQUES

The manufacture of FRP components generally involves the use of a mould (closed or open mould techniques), in which fabrics or resin impregnated unidirectional layers are used.

The closed mould manufacture involves the previous placement of the reinforcement in the mould, followed by the injection by pressure or vacuum of the resin to a closed volume and posterior cure at an elevated temperature, resulting in a component with the fibres parallel to the mould surfaces. In the Resin Transfer Moulding (RTM) technique (Fig. 2), fabrics are laid up sequentially under dry conditions.

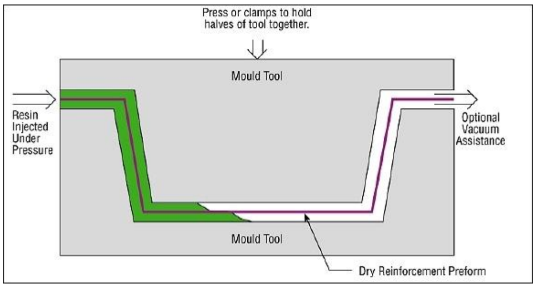

Fig. 2. RTM fabrication technique.

These can also be pre-pressed to the mould shape, together with aggregation with a binder. This helps to an easier insertion into the mould. A second mould tool is used to close the set, and resin is injected into the cavity. Vacuum can also be applied to the mould cavity to assist resin flow into the fabrics (vacuum assisted resin injection). Once all the fabrics have been impregnated, the resin inlets are closed, and the part is left to cure. Both injection and cure can take place at either ambient or elevated temperature.

By the opened mould methods, the component is fabricated by manual resin impregnation of the fibre fabrics, jointly with short chopped fibres, or by manual stacking of resin impregnated layers. In both cases the resin consolidation can be carried out under high pressure and temperature, or alternatively under ambient conditions. The pressure can be applied by a vacuum bag or an autoclave (a pressurized oven that subjects the component to the necessary pressure to assure compacting and temperature for the resin cure). The opened mould methods also allow the multi-directional orientation of the fibres. The manual stacking method for resin impregnated layers allows a total control of the fibres orientation and it is used for manufacture of small series that do not demand a high VF. As an example, in the spray lay-up technique (Fig. 3), the continuous fibres are chopped in a hand-held gun and fed into a spray of pre-catalysed resin directed at the mould. The component is left to cure under ambient pressure and temperature conditions.

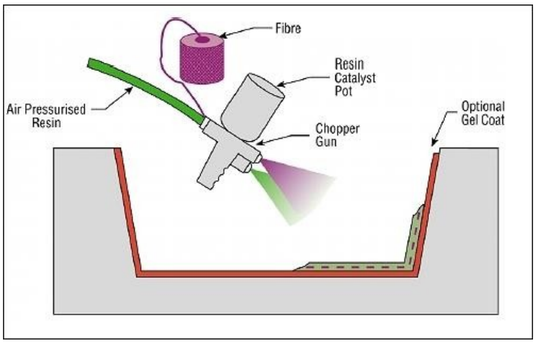

Fig. 3. Spray lay-up fabrication technique.

By hand lay-up (Fig. 4), the resin is impregnated by hand into the fibres, which can be in the form of woven, knitted, stitched or bonded fabrics. This process is carried out by rollers or brushes, eventually using nip-roller impregnators to force the resin into the fabrics. The parts are left to cure under ambient atmospheric conditions.

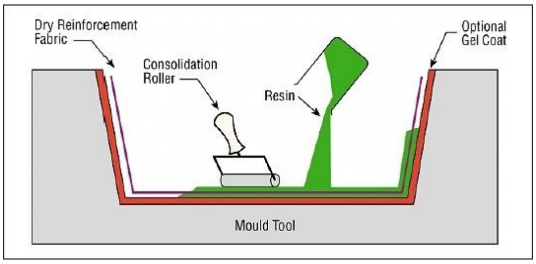

Fig. 4. Hand lay-up fabrication technique.

In the end, the choice of the most suited production method will depend on some factors, such as the materials chosen for matrix and reinforcement, or requirements of final product quality. The size of the series to be produced should also be considered. In fact, large series can justify a big investment in automated technology of manufacture. Oppositely, reduced or single series of production are normally associated to a small investment and correspondent bigger unitary cost of products.

APPLICATIONS OF COMPOSITES

The main applications of FRP include leisure or construction products (GFRP) and aerospace or sports/competition components (CFRP). For GFRP, typical applications are leisure boats hulls, pipes, reservoirs and pressure vessels, due to the excellent corrosion resistance. The Pluma gas canisters of GALP (Fig. 5), commercialized since 2005, are another example of FRP use for weight reduction, keeping the levels of security of traditional vessels. The final result is a lighter component, ergonomic and with better aesthetics than its predecessors. It is also the first gas canister to be totally recyclable.

Fig. 5. Pluma gas canister by GALP.

Vehicle components such as bumpers, wheel diggings or exterior panels of trailers, provide increased sustainability during their life span by the significant reduction of emissions. Actually, trailers designed with GFRP components give a weight reduction of ≈25% comparing with the metal equivalent. The trailer of Fig. 6 is almost totally constructed in GFRP of E glass fibre/vinyl ester matrix, including the floor, lateral panels, roof, doors and chassis.

Fig. 6. Trailer with extensive GFRP use.

The use of GFRP in the railroad industry also allows great competitive advantages in aspects as the maximum speed, reduction of fuel consumption, minor convoy inertia and higher load capacity. The possibility of modular construction with FRP components and quick assembly by bonding increases the production rate and eases the assembly, which reflects in a reduction of costs.

The use of FRP for the manufacture of wind tower helices allowed a considerable increase of their length due to the weight reduction, with the corresponding increase of working efficiency. The helices are currently constructed in GFRP with reinforcement of CFRP in the most loaded regions. Electricity poles are another possible application of GFRP. Their useful life, superior to 80 years, without maintenance makes them ideal for installation in remote areas. They isolate electricity, resist to corrosion and have reduced weight, which eases the transport and installation.

In Design, the use of materials as GFRP or CFRP makes possible the creation of parts with an innovative and attractive look, by using small thickness shapes whose construction in conventional materials would be impracticable by the conventional production processes, or rendered unfeasible due to strength or stiffness limitations. The use of FRP for these applications allows the design of products with the imposed characteristics added to a reduced weight.

Fig. 7. Bicycle with CFRP frame.

GFRP and CFRP are equally popular for competition sports equipment. GFRP tennis rackets allow the weight concentration in its edge and consequent increase of its performance. CFRP bicycle frames (Fig. 7) also benefit from a major weight reduction, and this specific product is actually under heavy development, namely in which regards to innovative fabrication processes such as filament winding or using inflatable mandrels.

The use of cryogenic fuel reservoirs for space rockets in CFRP allows a weight reduction between 10 and 15% comparing with the aluminium reservoirs, making possible superior loads or inferior launching costs and fuel consumption. The FRP is also used in unmanned aeronautic vehicles (e.g. Eagle-Eye Bell HV-911 Helicopter). The result is the reduction of weight and increase of the autonomy.

In sports cars, the CFRP use can bring a reduction of the components weight up to 75-80% in comparison with steel, 30-40% compared with aluminium and 50% compared with short fibre GFRP. The McLaren F1 was the first car of series production with an integral monocoque structure in CFRP, as well as exterior panels, resulting in a weight of 1140 kg. CFRP is also the chosen material for the construction of Formula 1 cars chassis due to the unmatched specific strength and stiffness. Usually, the main structure uses honeycomb sandwiches.

In civil and military aviation, the use of GFRP, CFRP, and even Kevlar® composites, is becoming more popular due to identical reasons. The commercial airplane Airbus A380, constructed in 2005, already uses FRP in several components such as the fuselage, wings and tail sections. Parts of the fuselage of this airplane are produced in aluminium strengthened with GFRP (material known as GLARE), because of a higher strength, superior impact behaviour, and better fatigue and corrosion characteristics. The Boeing 787 Dreamliner uses nearly 50% of its structure in FRP, which allows a weight reduction of 12%, with consequent reduction in the fuel consumption.

The reinforcement of concrete structures as buildings and bridges is another field of application of GFRP and CFRP, avoiding the corrosion of steel reinforcements and correspondent deterioration, particularly in submerged bridge pillars. These materials have also been applied for seismic reinforcement of buildings and bridges. GFRP or CFRP can equally be considered for the repair of structures such as bridges, having appeared in the last few decades as an economic alternative to the substitution of damaged beams.

BIO COMPOSITES

The bio composites, of still residual application comparing with the GFRP, are constituted by a vegetal or animal matrix and/or natural fibres of reinforcement (derived from plants or cellulose). The applications of these materials range from biodegradable and environmentally friendly components (Fig. 8) to biomedical materials for repairing or substitution of damaged tissues by external factors, illness or malformations, because of the possibility to attain identical properties, which cannot be achieved separately by a single material [4]. Thus, the behaviour of live structures of the human body is reproduced by biocompatible materials, preventing the death of involving tissues due to the implantation derived from the difference of mechanical properties. Also the fast bone growth and of tissues is made possible, which was not accomplished by metallic implants because of their superficial properties. Because of the similarities with the chemical composition of the human bone, the animal polymer matrix/ceramic reinforcement composites have been widely used in orthopaedic implantations. These biocomposites in particular also have as advantage the possibility to attain a widened gamma of mechanical and biological properties by the modification of the type and distribution of the ceramic phase in the polymer matrix.

Fig. 8. Inner panel of a vehicle door in hemp short fibres/polyethylene biocomposite.

Bio composites have received a lot of attention in recent years [5]. The Dutch company DSM, for instance, has been actively working on bio composites and it has recently introduced to the public (at the JEC Composites Show 2010 in Paris and at the SAE 2010 World Congress in Detroit) two bio composites for the automotive industry, as a response to the customer pressure for sustainable products.

Fig. 9. World's first outdoor bench fully fabricated respecting the cradle-to-cradle (C2C) sustainability concept, made of Palapreg® ECO P55-01.

One of these is Palapreg® ECO P55-01, a bio resin for automotive vehicle body parts, including exterior panels. It is made of 55% renewable resources, which gives it the status of the composite resin with the highest available bio content. Moreover, tests were already conducted, showing similar strength and production speeds to conventional artificial composites.Fig. 9 shows the world's first outdoor bench fully fabricated respecting the cradle-to-cradle (C2C) sustainability concept, made of Palapreg® ECO P55-01. The other product by DSM is the EcoPaXX™, a bio and high performance engineering plastic (polyamide). It benefits from a high melting point (≈250°C), low moisture absorption and excellent resistance to various chemical substances, including road salt.

FINAL REMARKS

Alternatives to conventional materials such as metals and petroleum-based plastics are urgently needed as fossil fuel supplies shorten and products become more expensive, while consumers and regulators demand solutions with lower environmental impact. Composites in general and more specifically bio composites represent a step forward in sustainable products and are starting to get attention by the industry. In this work, the basic principles, characteristics and possible applications of these materials were discussed in which regards to the state-of-the art developments.

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MULTI-SITE PRODUCTION NETWORK INTEGRATION MODEL

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Abstract: Today, organizations that wish to carry on the sustainable growing need a robust strategy to support business partners selection due to changing demands of consumers, reduced product life cycle, and competitive and globalised markets, which is increasingly more be carried out within the context of Virtual Enterprises. In this context, business partners selection decisions, at a strategic level, are focused on strategic items with both a high supply risk and a high profit impact. Therefore, strategic business partners selection decisions have to be taken in a real-time base, although preferably based on long-term historical information gathering, regarding potential business partners to be selected, from a set of ones available. Therefore, important information draws upon mutual commitments between the partners involved, as well as fixed costs upon selection of a new business partners in the form of investment in training, and technology, as well as significant costs of switching from one business partner to another, among other information, namely regarding penalties arising from historical data related to previous undesirable behaviours from past experiences with business partners, like unaccomplished due dates, or products requites, among others.

Since a certified business partner is a key component and a good resource for a purchaser in reducing such costs, estimation and selection of the potential business partners has become an important component of supply chain management and we are extending this idea to a multi-site production network of manufacturing organization model, based on the principles of a Agile/ Virtual Enterprise.

Keywords: Multi-site Production Network, Integration Model, Agile/ Virtual Enterprise.

INTRODUCTION

A multi-site production network (MSPN) can be defined as a set of geographically dispersed facilities that process products and that can be connected through a network. The main task of a MSPN is to manage the whole business partners (BPs), which may dynamically integrate this production network, in order to satisfy a given set of objectives, for instance, by deciding which partners are going to be chosen for accomplishing some production orders, in a certain specified time horizon.

The business partners may vary from manufacturing companies up to suppliers and customers, which also play an important role for reaching some objectives, therefore, it is also important to consider them into the MSPN as well. For this reason, selection of potential BPs has become an important concern of MSPN management and this is even truer in the today's globalized manufacturing market context.

The problem of BPs selection can be viewed as a multiple-criteria decision-making problem (MDP), where businesses express their preferences with respect to BPs, which can then be ranked, in order to be selected. Doing so, however, does not take into account the temporal evolution of BPs performances; neither can it be easily applied when considering more than one customer. To overcome these problems, we introduce a model for BPs selection that extends a classical model of multi-criteria decision-making model by introducing feedback, regarding previous information about relations with business partners and consider the inclusion of this historical information in the context of multiple partners, which include not only manufacturing partners, but also suppliers and customers, in terms of a linear programming model.

In order to enable a contextualization of the proposed model this paper includes a summarized review about some more or less closely related problems referred in the literature, namely about supplier selection problems. Next the proposed model for multi-site business partners selection (MBPS) is briefly described, based on classical multiple-criteria decision-making models extension, and finally, some conclusions are presented.

STATE OF THE ART

Due to its criticality, many authors have focused on the problem of identifying and analyzing supplier selection criteria. Already in 1966, Dickson [1] examined different supplier selection strategies by means of questionnaires that were distributed among selected managers from the United States and Canada. Clearly, as companies become more and more dependent on suppliers, outcomes of wrong decisions become more and more severe: for example, on-time delivery and material costs are both affected by careful selection of suppliers, especially in industries where raw material accounts for 70% or more of the total cost [2].

The problem of supplier selection can be easily understood as a multiple-criteria decision-making problem: businesses express their preferences on suppliers, which are then ranked and selected. However, as outlined by Sucky [3] in his work on strategic supplier selection, decisions in this field are made more complex by the fact that different suppliers usually have different performances with respect to different criteria: for example, the supplier who has the best quality performance may not have the best delivery performance.

Even more importantly, existing approaches of supplier selection neglect investment costs of selecting a new supplier and costs of switching from one supplier to another.

According to Kumar et al. [4], to improve the performance in different aspects such as decrease in costs by scraps deletion, reduction in defect products, improvement in flexibility in response to final customers needs, decrease in work completion time in each level of supply chain, supply chain should be integrated with suppliers well. The problem of choosing the best supplier is not limited to only suppliers or sellers. With a look at the literature, this can be inferred that decision making in this issue has different aspects and that supplier selection is one of those aspects. Researchers have introduced many systematic tools for the supplier selection problem.

The supplier’s selection problem is one of the most important components in supply chain management. In recent years, rough set theory has emerged as a powerful tool for supplier selection problem approaches.

The supplier’s selection is a multiple attribute decision making (MADM) problem. The decision makers (DMs) always express their preferences on alternatives or on attributes of suppliers, which can be used to help ranking the suppliers or selecting the most desirable one.

Moreover, it is assumed that the set of employed suppliers can be changed each period without cost.

Some other approaches are based on stochastic dynamic models for supplier selection, based on hierarchical planning approaches. According to those models an evaluation of alternative dynamic supplier selection strategies is performed.

Besides the existence of a wide range of contributions put forward, as stated by Omid and Morteza [5] existing approaches of supplier selection usually neglect the interdependencies in time arising from investment costs of selecting a new supplier and costs of switching from one supplier to another. Moreover, the multi criteria decision making were considered one of the most useful branches of decision making science, as many methods about multi criteria decision-making, such as analytical hierarchical process (AHP), multi criteria utility theory, linear weighting models, and TOPSIS have been developed, having all been applied for the supplier selection problem.

Another approach, based on rough set theory is a widely used tool in data mining and knowledge discovery. Up to present, the rough set approach has been also proposed to deal with the supplier selection problem under uncertainty. However, in the decision table of rough set theory, attribute values must be known precisely, which may compromise its useful application for solving these kind of problems.

Grey system theory is another kind of methods that are used to study uncertainty; it is superior in mathematical analysis of systems with uncertain information and is also being explored.

Up to present, fuzzy-based approaches have also been proposed to deal with the supplier selection problem under uncertainty. The advantage of grey system theory over fuzzy theory is that grey system theory considers the condition of the fuzziness, enabling to flexibly deal with the fuzziness situation [4].

MULTI-SITE PRODUCTION NETWORK

A multi-site production network (MSPN) can be considered as a network of different geographically dispersed facilities, where products are transformed and stored, and transportation links that connect these facilities. The major task of MSPN configuration (MSPNC) - the strategic level of MSPN management (MSPNM) - is the design of the MSPN in such a way, that a given set of objectives is achieved. MSPNC decisions concern the entire MSPN process. On the production side decisions about the location and capacity of plants are the typical tasks of MSPNC. On the distribution side, in general, the locations of warehouses have to be determined, among other important and fundamental decisions.

Multi-site production network (MSPN) is a concept that aims at integrating various processes and phases involved during several product lifecycles with people participating on each stages, from concepts, design, prototypes, developments, manufacturing, markets, selling, services up to re-cycles, reengineering and reverse-engineering processes and Figure 1 presents a summarized view of such an widened network environment, about an integrated Agile/ Virtual Enterprise (A/VE) architecture [6] as a MSPN, under the concept of Ubiquitous Manufacturing System (UMS) [7].

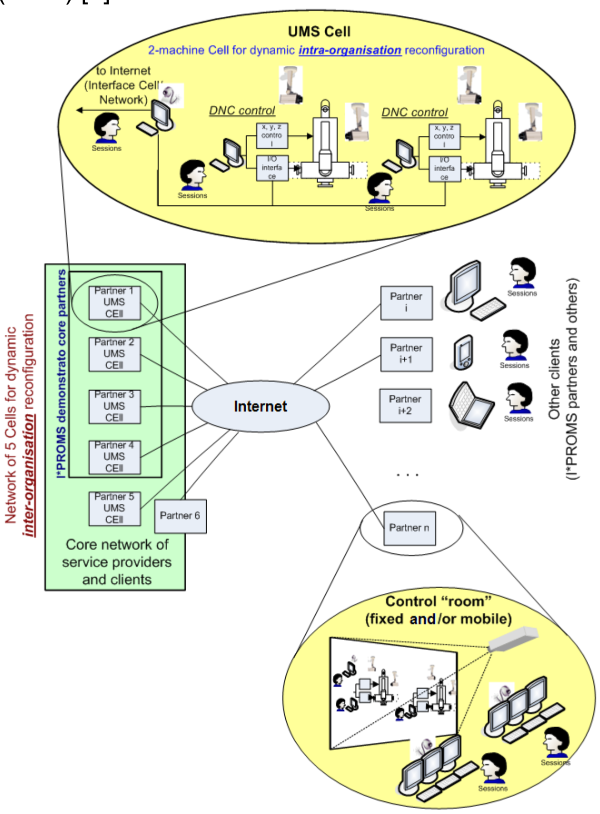

Fig. 1. Integrated A/ VE Architecture [7, 8].

An A/VE is a dynamically reconfigurable global networked organization, networked enterprise, or network of enterprises, sharing information and/ or knowledge, skills, core competencies, market and other resources and processes, configured (or constituted) as a temporary alliance (or network) to meet a (fast changing) market window of opportunity, presenting as main characteristics agility, virtuality, distributivity and integrability [9, 10].

Until now we do not yet know about any available single tool or package that can be termed as a MSPN integration package, therefore, being still emergent to try to make contributions on that direction. So, in this paper we make a contribution about a model for aiding organizations to collaborate in terms of business partners' integration, for being used under a context of Meta-organization environment, as shown in Figure 1. This Figure illustrates the integration of several manufacturing cells, which are remotely supervisioned and controlled through distinct business partners, connected and integrated in the context of Ubiquitous Manufacturing System based, namely, on Internet Technology (IT) support, as well as other monitoring and communication devices and tools.

Moreover, in this type of MSPN it is of greatest importance to pay attention to dynamic real-time based reconfiguration concerns.

Two critical factors against the concept of dynamically reconfigurable global networked structures, i.e., against reconfigurability dynamics and networking, can be identified [9]:

- the transaction costs, i.e. the firm reconfiguration cost, associated to business partners search, selection, negotiation and integration as well as permanent monitoring and the evaluation of the partnership performance; and
- the preservation of firm's knowledge on organizational and management processes, as it is the firm's competitive factor.

The efficient implementation of the A/VE model requires tools to overcome the networking and dynamics disabling factors.

The main tools suggested in the BM_Virtual Enterprise Reference Model (BM_VEARM) [7, 8], for managing, controlling and enabling networking and dynamics, overcoming the two critical factors against networking, are [9, 10, 11, 12, 13]:

- The market of resources, as the environment for enabling and management of efficient configuration, and assuring virtuality, at low transaction costs and reduced risk of knowledge leakage.
- The broker or organization configuration manager, which is the main agent of agility and virtuality, acting either between two operations of the A/VE (off-line reconfigurability, providing agility only) or on-line with the operation (on-line reconfigurability, providing virtuality and a higher level of agility).
- Virtuality makes possible the transition from one physical structure (instance) to another in a way that the enterprise or process owner is not affected by the system reconfiguration and

is not aware of the reconfiguration - the underlying service structure and reconfiguration process are hidden.

DYNAMIC VE RECONFIGURATION

Reconfigurability dynamics and business alignment as requirements for the A/VE model responsiveness to the market demands requires shorter product life cycles and shorter time to market, as well as forces the product life cycle to suffer frequent redesigns, which implies the requirement for increased dynamics to the A/VE model. Even A/VE tend to last shorter and shorter time, while simultaneously addressing a highly dynamic reconfiguration; an A/VE can have as many instantiations as required either by product changes or as a requirement of quality and competitiveness improvement, to assure a permanent alignment with such market demands.

The main critical aspects associated to the recent concept of dynamically reconfigurable global networked structures, corresponding to the A/VE model - precisely based on networking and reconfigurability dynamics - are the transaction costs and the leakage of private information [9, 10, 11].

Dynamic organizational models represent solutions for highly customized products, small series, in highly competitive and changing environments where permanent business alignment is crucial. Partnership stability is low (sometimes very low), dependency between partners is very weak and reconfiguration dynamics should be as high as possible, given the permanent monitoring of the structure to traduce the most competitive solution at every moment of the product life cycle [11, 12].

Reconfiguration, meaning substitution of resources providers, generating a new instantiation of the network, can happen mainly from three reasons [9, 10]:

1. Reconfiguration during the network company life cycle is a consequence of the product redesign in the product life cycle, to keep the network aligned with the market requirements.
2. Reconfiguration as a consequence of the nature of the particular product life cycle phase (evolutionary phases).
3. Reconfiguration can happen also as a consequence of the evaluation of the resources performance during one instantiation of the network, or voluntarily by rescission of participating resources, wiling to disentail from the network.

Therefore, we are able to state that the above mentioned dynamic reconfiguration requisites led to a need for multi-criteria decision-making model for VE dynamic reconfiguration support, as we are going to describe next, through our proposed linear programming model.

PROPOSED MODEL

In general, the aim of multiple-criteria decision-making is to find the best compromise solution from a set of feasible alternatives assessed with respect to a predefined set of criteria. This type of problems is widespread in real-life situations, and many approaches have been proposed in the literature to deal with this static decision process, from utility methods to scoring and ranking ones [13, 14], among other approaches, as we described before. However, when facing dynamic decision-making problems, where feedback from step to step is essential, very few contributions can be found in the literature [15]. Usually, dynamic multi-criteria decision-making belongs to spatial-temporal contexts, in that exploration of the problem might result in new alternatives being considered, others being discarded, and the set of criteria being similarly altered.

In this context, the problem of multiple business partner selection can be easily understood as a temporal multi-criteria decision-making problem: periodically and dynamically, businesses express their preferences with respect to business partners, which can then be ranked and selected.

Even by considering a temporal multi-criteria decision-model, however, does not take into account the possibility of planning for more than one business partner, which is the motivation behind this work, to introduce a multi-site integration model for business partners selection that incorporates a linear programming model to handle many-to-many relationships (a number of collaboration businesses with relation to several business partners), as illustrated through Figures 2 and 3 and described below.

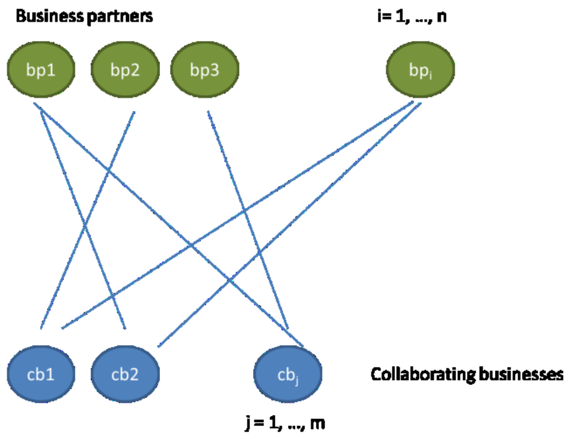

Fig. 2. Many-to-many relations between collaboration businesses and business partners.

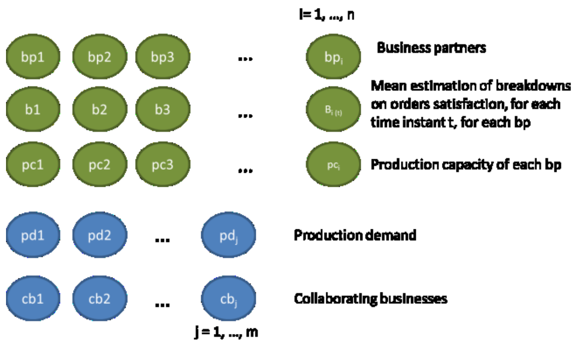

Fig. 3. MSPN Integration Model.

Let us consider a time instant t and m collaborating businesses (cbj), which are planning their orders to a set of n business partners (bpi).

Each collaborating business cbj, j = 1, …, m is assumed to have mean estimation of breakdowns on orders satisfaction, for each time instant t, given the corresponding historical information, for each business partner bpi, i = 1, …, n, denoted $\underline{b}$i,(t). Furthermore, each collaborating business has a certain production demand pdj, j = 1, …, m, and each business partner has a maximum production capacity, pci, i = 1, …, n. Moreover, the variables of the network of collaborating businesses and business partners includes the quantities xij, that collaborating business, cbj , j = 1, …, m, order from business partners, bpi, i = 1, …, n.

$$\text{Min } L = \Sigma_{(j=1,\ldots,m)} \Sigma_{(i=1,\ldots,n)} (\underline{b}_{i,t} * x_{ij})$$

$$\text{s.t.} \quad \Sigma_{(i=1,\ldots,n)} x_{ij} = pd_j \ (j=1,\ldots,m)$$
$$\Sigma_{(j=1,\ldots,m)} x_{ij} \leq pc_j \ (i=1,\ldots,n)$$

Therefore, in this proposed model the total lack of satisfaction levels of all collaborating businesses (L), in terms of the mean breakdowns of orders satisfactions, evaluated through a set of considered important data, is minimized.

There are some other similar linear programming models put forward by some authors, which usually consider the minimization of some typical costs, instead of the here proposed mean evaluation of breakdowns on order satisfaction, based on the past performance of business partners, according to an historical repository for each business partner, which we believe may be a good approach for more closely treat the reality, in terms of the previously referred lack of satisfaction that can be measured through an aggregated factor, including all the considered relevant penalties related to a set of distinct parameters for enabling to account a more or less widened range of factors, which may led to the necessity to reject or accept any of the candidate business partners. Examples of such factors may vary from simple sums of times each supplier did fail a deadline for assembly components delivering, up to factors for evaluating more subjective aspects, namely regarding some previously formed image about some supplier, regarding, for instance, third party opinions registrations, or previous delivers of products without satisfaction of imposed product specifications, among other business partners' evaluations.

CONCLUSION

In this paper we described a proposed model for multi-side production network integration model for business partners integration, where multiple businesses may select several business partners, in the context of an Agile/ Virtual Enterprise environment, which extends classical existing models, namely for suppliers selection, by incorporating it into a linear program, that allows selection of the optimal quantities to be ordered from the business partners, through a network of collaborating businesses, therefore, allowing to consider a network of businesses partners instead of a single one and multiple collaborating businesses, in a real-time basis, within a context of an Ubiquitous Manufacturing Network model.

We believe that our proposed approach has the potential for providing valuable decision-support in business partner integration in an A/VE network that can be exploited to improve the management of multi-site production network environment.

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RESEARCH OF THE EFFECTS OF SCALE FORMS ON READABILITY OF ANALOGUE VISUAL DISPLAYS

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Abstract: Nowadays analogue visual displays have frequent application in many industries, such as automotive. Before more than half of a century, certain number of researches was performed, regarding the suitability of individual characteristics of analogue visual displays for reading. However, conclusions from these studies regarding the conveniences of basic forms of the scale for reading (circular, horizontal and vertical) have been contradictory. Given this fact, the aim of this paper is to determine the convenience for reading the three basic forms of analogue visual displays. The results of this study indicate that the circular form of analogue visual display has a significant advantage in terms of readability, in relation to the linear forms. It was not found a significant difference in readability, between horizontal and vertical forms of analogue visual displays. Recommendations for designing of a man - machine interface are given, regarding the application of different forms of analogue displays.

Keywords: ergonomics; design; user interface; human factors

INTRODUCTION

The basic purpose of displays in the context of an interaction between man and machine consists in registering, monitoring and interpretation of a change of machine states, a man and their environment while performing an operation, or after its completion when it is needed [1]. In practice, a man usually performs three types of readings from the display. These are quantitative, qualitative and control reading. For the purpose of quantitative reading, most often are used analog and digital displays [2].

Analogue displays (indicators) are those displays for which the position of the pointer relative to the scale is analogous to the value that is presented [3]. Analogue displays have an advantage over the digital displays, when used for qualitative or control reading [2]. They are superior to the digital, also when it is necessary to show rate of change of a variable [4]. Although the studies that have dealt with the comparison of analogue and digital indicators showed that the speed and accuracy of quantitative readings are higher for digital than analogue indicators [5], analog indicators continue to have very broad application for quantitative type of reading. This is particularly true when are observed the displays that are represented in cars and other transport means on the ground. It may be noted that over 90% of the vehicles nowadays are available with analog displays.

Exploring of the properties and improving of the characteristics of analogue visual displays began before more than half of a century. These researches have caused the appearance of the first recommendations regarding the design of the indicators, which are further led to the formation of certain national standards, which relate to the displays. However, following the initial researches, which were performed with analogue displays, there was a period of lull during several decades, in which there were hardly any scientific studies on this topic. On the other hand, the form of analog visual indicators in recent years found its practical application in modern head up displays. For this purpose, they are often combined with a form of digital display. An example of combined use of analogue and digital display for making of head up display is shown in figure 1.

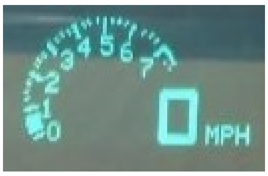


Fig. 1. The combination of forms of analogue and digital displays in modern head up displays in automobiles, on an example of Chevrolet Corvette Z06.

When we want to perform the quality assessment of an analogue visual display, it is necessary to determine its readability. Readability is a broader concept of legibility and visibility, because it involves the interpretation and understanding of the presented information. When talking about the analogue visual displays, it is essential that the user also make interpretation of the information that indicates a pointer on the scale of a dial [2], depending on the conditions of presentation. In this regard, we can distinguish formal and meaningful readability. The totality of characteristics of a display that determine the process of perception in terms of speed and accuracy of a signal receiving in given conditions presents the formal readability. On the other hand, the totality of characteristics of a display that determine beside the perception of a signal also their understanding, presents the meaningful readability [6]. The concept of readability in general includes the formal and the meaningful readability.

From an ergonomic point of view, there are two important aspects to be taken into account when determining the readability of certain analogue display. These are speed and accuracy of reading. The reading accuracy is determined by the number errors.

PROBLEM

As previously mentioned, before more than half of a century, certain number of researches has performed, in order to determine the suitability of individual characteristics of analogue visual displays for reading. However, conclusions from these studies regarding the conveniences of basic forms of the scale for reading (circular, horizontal and vertical) have been contradictory. Thus, for example, Murrell quotes [7] one of the earliest studies of its kind that was conducted by Sleight. He examined the convenience of some forms of dials of analogue visual displays. From the results of this study, we can see that in relation to the accuracy of reading, the circular form of display is more convenient than the horizontal, while the least favorable option for reading is the vertical display. However, also there are researches were as the final result were obtained a different order of dials in terms of the readability. Thus, stating the final results of his research Naylor points out that the straight line dials are more readable then circular dials, while horizontal are more readable than vertical [7]. Graham and Thomas obtained similar results. They point out that the horizontal displays are easier to read than circular, while the circular are easier to read than vertical [7]. Ivic quotes [8] that the circular shape of the scale is more convenient for readouts from the horizontal, while the horizontal are more suitable then the vertical. Subsequent research of Elkin has confirmed the results of Sleight [7].

It may be noted that the results of these studies do not indicate reliable a which form of the scale is most convenient for reading. After the initial research conducted on this subject, in recent times have not conducted studies that have dealt with this issue. However, when observing an analog visual displays that are represented in modern automobiles, it can be noticed a distinct predominance of circular scales, in relation to the horizontal and vertical form of the scale. One gets the impression that the horizontal and vertical form of the scale is almost excluded from production, when viewed segment of the automotive industry. Given this fact, as well as that the results of previous studies do not provide an obvious advantage to a particular form of display in terms of readability, the aim of this paper is to determine the suitability for reading the three basic forms of analogue visual displays, circular, horizontal and vertical, on the basis of an application of the controlled experimental procedure and adequate analytical processing.

METHOD

As in other experiments of this kind, to test the readability of the visual analogue displays the tachistoscopic method was used. As an instrument for this research, the projection tachistoscop was used. It is the device, whose basic purpose is to emit visual stimuli of short duration. Exposure time of each analogue display was fixed and it was 0.5 s.

In determining the exposure time, several important details were taken into account. First of all, the chosen exposure time allows subjects only one glance in the direction of the place where a display emits. This exposure time also corresponds to the time that is necessary (available) for a driver to read the information during driving, when one takes into account the need of drivers to monitor the situation outside the vehicle on the theoretically continuous basis. Also, the selected exposure time is short enough so that it leads to making mistakes in reading, if the shape of analogue display is not adequate. Accuracy of reading, i.e. readability, actually determines on the basis of errors that subjects make during readout. Test measurements with shorter exposure times from 0.25 s to 0.12 s led to the too high percentage of errors in reading, so they were rejected for the purposes of this study.

In this study, the readability of the visual analogue display with the circular (C), horizontal (H) and vertical (V) form of the scale was determined. Since several other characteristics of display and conditions under which the experiment is performed can also influence the results, efforts were made to eliminate their influence as far as possible. For this reason, for all three forms of the scale, identical division of the scale was chosen, where the value of the smallest divisions on the scale was equal two measurement units. Scale range (from the smallest to the largest value) was also identical for all three types of scales. Alphanumeric values in all three cases were located on the exterior side of the scale, i.e. on the opposite side of the scale in relation to the pointer. The pointer had a tapered shape and did not exceed a mark on the scale, which could lead to the reduced visibility. When designing the size of scale marks, consistency was taken into account also, while for their creation recommendations according to Woodson [9] were used. Given that these characteristics of analog indicators were identical for all three types of scales, their impact was identical. Accordingly, the difference in readability could be only the consequence of the scale forms.

Other conditions under which the experiment was performed were also identical for all three types of analogue visual displays. In order to avoid the appearance of glare on the projection screen from the natural source of light, the laboratory where the experiment was carried out had the curtains on the windows. The distance from the subjects to the projector screen was identical. The distance from respondents to the projector screen is determined in accordance with the recommendation by using the formula [10] l = 200 h, where h is the size of alphanumeric characters displayed on the screen. In this way it is provides adequate visual acuity in reading, which corresponds to the situation where in the real conditions of observation a display is located at the recommended distance from an observer.

Each analogue visual display C, H and V was presented 10 times with different integer values, which a subject should read off. Order of forms of indicators and values that are displayed on them, were determined using the table of random numbers. The study comprised 34 subjects aged between 20 and 30 years. All subjects have had the normal visual acuity. The task of subjects was to note down values that are read into the prepared tabular form, following the presentation of each analogue visual display.

RESULTS

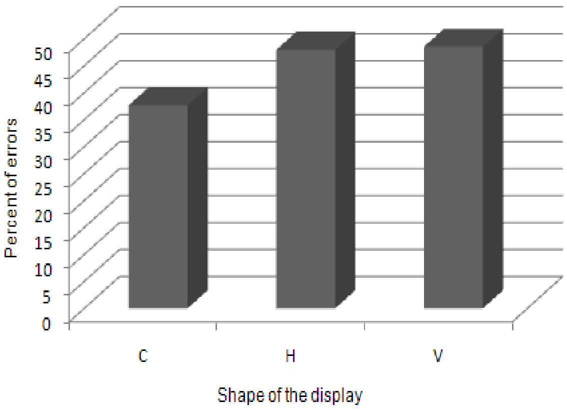
Table 1 gives an overview of the total number of correct answers of all subjects, for each of the studied forms of the display.

Figure 2 shows the percentage of errors that were made during the reading of the displays, for a circular (C), horizontal (H) and vertical (V) form of the scale. It is possible to see that the smallest percentage of error was obtained with the circular form of the display (37.64%), while the percentage of errors with the vertical form of the display (48.52%) is slightly higher than that of the horizontal form of the display (47.94%).

Table 1. The total number of correct readouts for circular, horizontal and vertical form of the scale.

Form of analogue visual display		
C	H	V
212	177	175

Fig. 2. The percentage of errors in reading, depending on



the form of the display.

ANALYSIS OF RESULTS

It is necessary to determine whether exists significant differences in readability between the basic types of analogue visual displays. In this regard, first it is necessary to determine whether exists a general dependence between the readability (reading performance) and the analogue visual displays. In other words, it is necessary to check whether dependence exists between the accuracy of reading and form of the scale. If this dependence exists, then it means that the shape of the scale affects the accuracy of readings.

We set the hypothesis that the accuracy of reading is not dependent on the shape of the scale. This hypothesis will be checked using the χ^2 test of independence of modalities. Since the value obtained by calculating χ^2 (10.3) is greater than tabular value (for the significance level of 0.05), the hypothesis that reading accuracy is not dependent on the forms of the scale is rejected. Therefore, the shape of the scale has an impact on the accuracy of reading.

Since the readability depends on the shape of analogue displays, it is necessary to determine additionally which shape is best in terms of readability. However, the application of the χ^2 test can not provide this type of information. To compare the readability of the main forms of analogue visual displays, we will use the t - test for dependent samples, based on the paired observations. Samples are considered as dependent, because the results obtained from measurements on the same subjects. Paired observations were used to avoid influence on the results that would exist, if different groups read values only with certain displays.

First, we will compare readability of the circular and horizontal displays by using t - test. We will test the hypothesis that there is no difference in readability between the circular and horizontal displays. On the basis of calculation, we obtain that the absolute value for t equals 4.63. Given that the absolute value of t is higher than the tabular value (for the significance level of 0.05), the null hypothesis was rejected that there is no difference in readability. Thus, the circular form of analogue visual display is better in terms of readability than the horizontal.

Now we will compare the readability of the circular and vertical displays by using t - test. We will test the hypothesis that there is no difference in readability between the circular and vertical displays. On the basis of calculation, we obtain that the absolute value for t equals 4.79. Given that the absolute value of t is higher than the tabular value (for the significance level of 0.05), the null hypothesis was rejected that there is no difference in readability. Thus, the circular form of analogue visual display is better in terms of readability than the vertical.

We will compare now the readability of the horizontal and vertical displays by using t - test. We will test the hypothesis that there is no difference in readability between the horizontal and vertical displays. On the basis of calculation, we obtain that the absolute value for t equals 0.135. Given that the absolute value of t is less than the tabular value (for the significance level of 0.05), the null hypothesis was accepted that there is no difference in readability. Therefore, it cannot be argued that the horizontal form of the display is easier to read than the vertical, and vice versa.

DISCUSSION OF RESULTS

The results of this study are partly consistent with the results of certain studies that were performed before. In this regard, in the present study, the circular form of display is identified as the most suitable form of display for reading, i.e. identically to the results that are presented by Sleight, Elkin [7] and Ivic [8]. However, the results of this study differ from previously mentioned, because in this study it is not found a difference in readability between the horizontal and vertical forms of the scale. These results also differ from the results of research that present other authors, such as Naylor, Graham and Thomas [7]. According to these authors, horizontal displays give the best results in terms of readability. Also, these authors have concluded that there is a difference in readability between the horizontal and vertical displays. In this paper, the existence of such difference is not confirmed.

CONCLUSION

The results of this study that are based on the application of tachistoscopic method indicate that the circular form of analogue visual display produces better results in terms of readability, in comparison with the horizontal and vertical forms. Based on the number of errors made in reading, the analogue visual displays of circular form are for 10.88% more readable than the analogue visual displays of vertical form. Also, the analogue visual displays of circular form are for 10.3% more readable than the analogue visual displays of horizontal form. Between horizontal and vertical forms of the scale, there was no significant difference in readability. Given this, the analogue visual display of the circular form can be recommended as an appropriate solution, when considering various alternatives during the design phase of a man - machine interface. Domination of application of the circular form of analogue visual displays can be considered as justified in the automotive industry.

The horizontal and vertical form of displays can be used when it is not possible to install the circular form of a display, due to existence of some physical limitation. In this case, since there was no significant difference in readability between the horizontal and vertical forms of displays, priority should be given to the form that is in accordance with certain space limitations and the layout of components.

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COMPARATIVE ANALYSIS BETWEEN SCHEDULING TOOLS FOR CUTTING SHEET METAL INDUSTRY

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Abstract: In order to be competitive, companies need to embrace sustainable policies and practices. Company leaders are taking a new stand on sustainability, recognizing that there is opportunity inherent in the need to provide solutions to the world's environmental and social challenges. This paper addresses a very common objective in Industry: how to radically improve efficiency for core processes and activities, in order to reduce waste and resources consumption, through the use of operational planning tools.

The present paper summarizes the research work conducted in a metal cutting sheet manufacturing company. The study involved the analysis of the company production process and the investigation of the working methods in order to evaluate material consumptions, response time and overall plans efficiency.

Keywords: Production Planning and Programming, Scheduling, Scheduling Tools Technology.

I - INTRODUCTION

As a result of markets globalization and the growing competition, a constant innovation in products, production processes and services is needed. The competitiveness of a company is directly related to the level of tactical and operational optimization for manufacturing operations in the production systems. With a clear objective to reduce costs and production time, increase quality and responsiveness to new products, it becomes essential to implement sustainable practices in the production systems.

For organizations, the awareness that the planet's resources are limited is driving them to apply a sustainability performance framework [1]. With this performance framework, metrics to measure processes and manage social, environmental, and economic impacts, enables management to create enduring value for multiple stakeholders. Leading companies increasingly are examining the impacts of their products, services, processes, and other activities more broadly. They are seeking for more sustainable approaches to preserve resources, reducing waste and using available capacity in a more eco-friendly manner.

The present work addressed this major topic through the work conducted in sheet metal cutting Portuguese SME company. In this case study research work, the main focus derived from the aim to implement sustainable performance practices that support process assessment and optimization.

Typically, metrics must be developed to measure the impact that the inputs have on the processes and to translate the impact of the processes on goals and objectives of the organization. In the current case, the company aims to create a more efficient system to tackle much of the requirements proposed by the company and customer needs. The company presents a repetitive but not constant manufacturing production model. The services provided are constant, but their demand is fluctuating. The operations planning is complex and becomes necessary to sequence in detail (schedule) the production in order to optimize the consumption of resources, reduce waste and meet the operational needs of the company.

In order to improve performance metrics related with company's main processes, the company management established as main objective improve the production scheduling in critical processes along the production flow. Aligned with this management objective, the current research project defined as main goal the evaluation of the existing scheduling approaches and the assessment of the main efficiency indicators for these critical processes. As complementary task, the project aimed to validate the configuration data used from the current scheduling tool and perform a comparative analysis of solutions of other tools developed for the same purpose.

The following sections of this paper are organized as follows: section II presents the company and their main features; in section III the scheduling problem of the company is presented; section IV presents the scheduling computational tools that used in this study; section V makes analyses of the current production metrics of the company. Section VI shows and comments the computational study carry out and finally section VII reports some final comments and conclusions.

II - FACTORY PRESENTATION

In Portugal, the stainless steel industry is a market in expansion due to growing recognition of the qualities inherent to this type of material and possibility for industrial and domestic applications. In addition to solidification of the use stainless steel material in current applications, there is an increasing use of this material in other fields namely related to the sustainability issues due to its high reusability.

Founded in 1998, the case study company is a leading provider of products and services in the national steel industry. With the growing volume of business the company solidified its market position having at the present time, partnerships with major stainless steel producers worldwide. The company acquired in 2006 a new plant to increase the range of services and quantity of products available. With this acquisition, the company was able to acquire the necessary equipments for cutting and surface treatment of metal sheet, the main focus of this study.

According to the literature [2] we can characterize the production system as Table 1:

Table 1 – Company production process characterization

Parameters	Classification
Material Flows	• Continuous
Costumer relationship or Operating Metod	• Per Order and to Stock Manufacture
Produced quantities of one product	• Small Series (batch production) • Big Series (serial production)
Variability of Goods Produced	• Similar
Nature Products	• Discrete • Process
Characterization of Search	• Unpredictable demand Variable Search
Production Space	• Concentrated

The study addressed the company production system mainly one line of metal sheet cutting and a line for metal surface treatment. Although there are other production lines in the company, this initial study focused primarily on these two lines, namely due to its resource consumption and high efficiency dependency to good scheduling plans.

The company has a very linear production system organized as job-shop, with a small number of machines required to process the main components for the final products. The tasks have at most one operation on each machine, and the operations can be one of three types:

- Cut;
- Cut and superficial treatment;
- Superficial treatment;

The operative plan for each equipment is individual and distinct for each operational order as the restrictions (start and due dates are negotiated for each order individually with the customer and other resource usage restrictions).

Each machine (cut and superficial treatment) needs a constant human monitoring and intervention for the correct processing. Also is not scheduled correctly it produces significant waste and consumes significant amounts of wood packaging material.

III - PRODUCTION SCHEDULING

With the demand growth, a wider range of customers and increasing variety of products it has become visible the increase of complexity in the order management function. Nevertheless it is essential that each order has to be planned, processed, monitored and delivered on time in order to sustain the market position of the company. The correct order management function is essential to reduce any process errors, minimize production and delivery delays, efficient use of resources and minimize waste. Therefore proper scheduling planning and production control system plays a major role for the overall sustainability of the company.

Problem Description

The company has an information system for production management based in Manufacturing Resource Planning (MRP). The repository of information is comprehensive and has the necessary data from material needs for the production of manufacturing orders to the fixed stocks numbers of finished products.

In order to support the detailed planning (scheduling) the MRP system provides the data containing the information necessary for production of all manufacturing orders. This data is provided through a file that is send to the scheduling tool. All tasks information including start and due dates, precedence’s, machines, quantities, etc., are included in this file. The scheduling system is only responsible for creating the scheduling or detailed plan.

The material flow for the studied process is described in the figure 1:

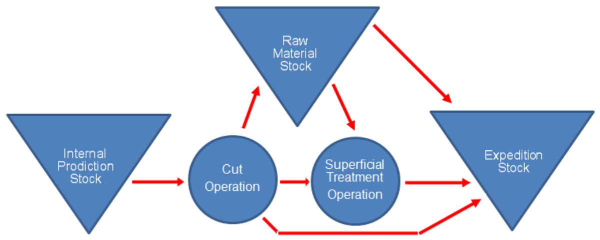

Fig. 1 - Material Flow

The material flow goes along most of the times the horizontal path, which is composed of four central steps: buffering of raw material, cutting operation, operation of surface treatment and final stock for shipment. In uncommon cases, there may be an intermediate buffer between the cutting and processing when a lot may only need to be cut and sent directly to the intermediate or final stock. Due to its characteristics, the material flow in this case could be considered as a Flow-Shop, since the products always follow a single path in its production process. Viewed in this way, there are several possible paths, and according to literature [3] since a Flow-Shop is a special case of a Job-Shop, it was considerer in this situation for simplicity a Job-Shop implementation. Therefore the problem in this case can be characterized as:

Table 2 - Problem Description

- A set of n jobs with one or two operations (multi-operation) available for processing at the moment according to the results of the MRP for a time span of seven days (approximately);
- The allocation of operations to machines is already pre-defined, therefore, our scheduling problem can be summed up in a sequencing problem;
- Preparation times for operations are dependent on the result, so are not included in processing time and are treated separately by the company for its scheduling software;
- The operations cannot be stopped;
- There are no precedence constraints between operations of different tasks
- Each machine can only process one task at a time;
- Each task can only be processed on a machine at a time;
- Are previously known attributes that describe the tasks;
- Each task corresponds to a product manufacturing linear structure;
- All tasks have equal priority order;
- The manufacturing environment is static, from one to three days;
- The company has in most cases as the objective function minimize the *makespan* (last proceeded task finish time) of the scheduling;
- Due to the high quantity of products produced by the company and the constant creation of new codes, the values of time are not completely correct, there is a high lack of time to set up mainly of machines;

IV - COMPUTACIONAL APLICATIONS

In order to deal and assess the scheduling problem, two scheduling applications were compared. The first proposed scheduling application is part of a project developed in Superior Engineering Institute of Porto ISEP [4] called MADScheGATS. The second application, Lekin, is a demo version of a application available in the internet [5]. At the end of this paper it is presented the conclusions achieved from the comparative analysis carried out to evaluate the detailed planning process in the company. In the conclusions it is also shown the advantages and the disadvantages of the current planning methodology namely to the business sustainability issues.

MADScheGATS

This software was developed in GECAD - Knowledge Engineering and Decision Support Group at ISEP. The name *MADScheGATS* derivates from *Multi-Agent System for Distributed Manufacturing Scheduling with Genetic Algorithms and Tabu Search*, and is a system where a group of distributed, autonomous and cooperating agents tries to solve scheduling problems.

This software allows to solve problems with a hybrid scheduling module in which a community of distributed, autonomous, cooperating and asynchronously communicating machines tries to solve scheduling problems.[4]

The *Multi Agent System* (MAS) uses a manufactory scheduling model of resources represented through agents and the tasks are performed in a distributed environment using cooperation and coordination among agents. [6]

The agent concept can be found in a large number of applications such as software engineering, artificial intelligence, human-computer interaction, distributed and concurrency systems, computer-supported cooperative work, control systems, decision support and electronic commerce.

The mains innovations in this software to the others is the integration of a Hybrid Scheduling Module that is a combination of Taboo Search and Genetic Algorithm based method and a mechanism for inter-machine activity coordination, with the objective of coordinate the operations in the machines using the constraints of their jobs. The system incorporates a module of dynamic adaptation to that is responsible of new jobs arrivals or cancelations. [4]

Lekin

The Lekin - *Flexible Job-Shop Scheduling System* is scheduling software developed at the Stern School of Business, NYU. Lekin starts as an educational tool for the introduction of scheduling and his features to the students.

Lekin application solves the scheduling problem after the individual introduction of all information for each task. It is an application with features similar to previous one having basically the same Dispatching Rules and Built-in Heuristics, but with the possibility of including the setup times matrix. Is free demo Software that can be found in the internet[1].

V - VALIDATION OF DATA ENTRY IN THE CURRENT SCHEDULING TOOL IN THE COMPANY

The company has a set of data associated to each product produced. This data is very important for the schedule as it contains the precedence, the machines used and the times of each operation (run times and setup times

Problem associated with the validation of the entry data

The input data required for the scheduling problem must be the most reliable as possible, in order to achieve valid results. Therefore, it was necessary to validate the data available in the company, before proceeding to the simulations of scheduling applications. In the following section it is presented a checking and validation of the operation times available in the data repository.

Time Determination

The study of time is related with the estimation of the interval of time required for a qualified person or machine to perform a given operation. The setup time is the time require from the last good piece produced from a lot (task) to the next good piece produced from the following lot (task).

The company have a large set of products; therefore it was necessary to create a product family scheme for the time definition. The products were grouped by is similarities in production and considering no setup times between each other.

In the current model of the company, the setup time for each operation was associated to the production time of a product. Since the setup time depends of the preceding operation, it was necessary to create a setup matrix between the different product families. After a measurement analysis of the different operations in the equipments and a comprehensive system analyses in the company, the setup matrix between all the families was determined.

With the purpose of validating the current production times present in the Information System in the company the produce times it was necessary to collect the measurements during the normal operation of the company for each product under study.

Time Results

With the time durations collected in the company it was possible to determine that the current data model of setup times wasn't accurate as it is possible to confirm in Fig. 2. This figure represents graphically the differences between the current setup times in machines A and B in study when the setup occurs from a product of family that we call "*a"* and other called "b". It is possible to state that in *Machine A* the setup average time has a level higher when compared with the measured values. In *Machine B* the opposite happens, the current values in average are lower than ones measured during the study.

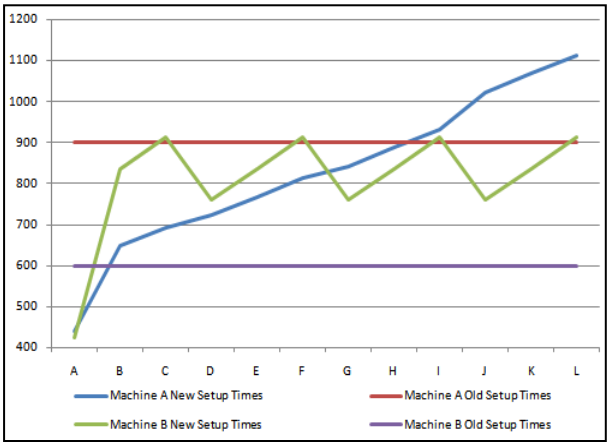

Fig. 2 - Setup Times Comparison

VI - COMPUTATIONAL (SCHEDULING) TOOLS EVALUATION

For the tests it was selected a 6 days' time horizon of production in the company in which was identified a set of 62 tasks for each plan of tests. For a correct assessment of the scheduling applications and evaluation of the results, a set of three types of simulation tests were designed.

Each set of tests have the exactly same Parameterization, Dispatching Rules and Objective Function. The difference between each set is the entry data treatment and setups. The three simulation test plans are presented in the next table.

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1 http://www.stern.nyu.edu/om/software/lekin/download.html *(Acceded in March 2011)*

Table 3 - Simulation Plans

Simulation Plans	Software 1		Software 2	
	Name	**Features**	**Name**	**Features**
Plan 1	*MASDSCHEGATS*	Runtimes and existing setup	*Lekin*	Runtimes and existing setup
Plan 2	*MASDSCHEGATS*	Execution times and certain existing setup	*Lekin*	Execution times and certain existing setup
Plan 3	*Lekin*	Execution times and certain existing setup	*Lekin*	Execution times and setup certain

Plan 1

Objective and Differences

The main objective is to have a first perception of how the programs behave with the tasks in the current conditions present in the company. It also enables a later analysis of the behaviour of scheduling operations using the values from the production times employed by the company and the values collected during the study. The simulation plan is different in terms of both processing times and setup.

Results

Table 4 - Results for Plan 1

Plan 1		
Software	*MASDScheGATS*	*Lekin*
Makespan	2549	2664
Max. Tardiness	0	0
Number of tardiness	0	0
Sum of tardiness	0	0
Time of Production	2689	2618

Results Analysis

The result analysis shows that there are no job delays in either tool, so we can consider that in this aspect the two applications are equivalent. On another hand, the total sum of production times is slightly higher in the case of MASDScheGATS, however, this late application provides the best solution for our objective function in about two hours apart, thus making this the schedule that best meets the requirements for this level of simulation.

Plan 2

Objective and Differences

The definition of this plan 2 intended to analyze a sample of orders using the times from the previous study, with the aim of studying if an adjustment of the current production times (at the moment used in the company) has in its scheduling application can result in lead time values closer to reality.

There is a fundamental difference that distinguishes this plan from the previous. With this plan, the production times are changed to reflect the process duration time more accurately. These latest values are closer to the reality of day-to-day work since, they have been collected during the operation period of the company.

Results

Table 5 - Results for Plan 2

Plan 2		
Software	*MASDScheGATS*	*Lekin*
Makespan	2543	2543
Max. Tardiness	51	0
Number of tardiness	1	0
Sum of tardiness	51,25	0
Time of Production	2364	2376

Results Analysis

With this plan, the application MASDScheGATS shows a lower value for the sum of production times. On the other hand, the values for the objective function are similar. In this simulation plan it is possible to identify a delay of 51 minutes, which means that the task would only be completed after the agreed deadline, that fact may bring cost penalties for the company. This situation poses to the decision-making agent, the necessity to consider what the most important factor is: the reduction in the sum of production times, or the delivery delay. From this analysis the decision-making agent should make is conclusions after deliberating what sequence to use.

Plan 3

Objective and Differences

The purpose of this third simulation plan is to assess how the setup matrix, as studied above, would interfere with the schedule for this company. Lekin program includes a parameter field for entering a setup matrix for each of the company's machines, thus enabling the creation of a schedule that tends to group the operations of the same family of products, creating a sequence production orders that enable the transactions to be processed more quickly and with less consumption of materials.

Results

Table 6 - Results for Plan 3

Plan 3		
Software	*Lekin* without setup	*Lekin* with setup
Makespan	2543	2543
Max. Tardiness	0	0
Number of tardiness	0	0
Sum of tardiness	0	0
Time of Production	2376	2296

Results Analysis

The purpose of this simulation plan is to analyse if a matrix of setup will decrease the times of production and of the objective function. From the results table 6 is possible to confirm that the sum of production time have decreased 1 hour approximately, thus giving importance to the need of including the more realistic setup times. On the other hand, the objective function was unaffected because in the studied scheduling plan it was a small number of tasks to do, and the gap between the operating times and the time available to perform the tasks was sufficient.

RESULTS ANALYSIS PLANS

Analysing the simulation plans under study with respect to the temporal distribution of these and the implications from use of the new determined production and setup times, it is possible to observe the difference in orders distribution in Table 7. Therefore, the change of duration for certain occasions caused a modification of the tasks distribution in the program MASDScheGATS, but keeping all other finishing at the same time. Also observed through the comparison of the different orders to be delivered, there is a constant trend of the application with the adjustment and anticipation of tasks, thus avoiding production bottlenecks and creating a more continuous production with fewer delays. In the case of Lekin it was found a slightly greater variation in the orders distribution in terms of the tasks sequence for the last days.

Table 7 - Orders Distribution

	Day	1	2	3	4	5	6	7
Plan 1	MASDScheGATS	12	11	7	8	17	7	0
	Lekin	13	10	7	9	15	8	0
Plan 2	MASDScheGATS	12	11	7	7	19	6	0
	Lekin	13	10	7	9	18	5	0
Plan 3	Lekin	13	10	7	7	18	7	0
Due Dates		8	15	7	6	14	13	1

In order to analyze the implications of the new processing and setup times the present work focused their attention in the Lekin results on each plan simulation and make comparison analysis.

Table 8 - Compiled results of simulation plans

	Setup and Production Times of in the Company	*Setup and Company New Times*	*Setup of the Company and New Production Times*
Makespan	2644	2543	2543
Tardiness Times Sum	0	0	0
Production Times Sum	2618	2376	2296

Table 8 confirms that the inclusion of both production times as well as the setup matrix has improved significantly the solution, allowing the purpose to maintain *makespan* goal constant but increasing the sum of production times in 5 hours and 30 minutes approximately. Thus, this justified the company's need to use the new production times and format their setup data set in matrix form.

With the results obtained from the 3 simulation plans, it is possible to make a global analysis taking into account two aspects: The comparison between the two scheduling applications; and the implications of the use of production times and setup calculated during this work comparing them against those that are employed by the firm. With respect to the first point, given the analysis of results previously made for simulation plans 1 and 2, it is possible to infer that the application MASDScheGATS showed better results than Lekin. Given the sustainability implications of the calculated times in the simulation results, it is clear to conclude from the results, that both the times of production and the setup matrix time should be updated and employed in the company for scheduling purposes.

From the result analysis found in production schedules within the company, it is clear that related with the issue of fixed setups, the company ends up creating a slack time in the process, i.e. when an order is released to manufacturing production it is always associated with a fixed setup time. This is prejudicial, since the machine operator groups the orders by product family, originating in the first place not a precise implementation of the proposed schedule by the application that in reality may prove unfavourable to the company, and secondly will result in a decrease in the actual setup times, creating slack in the production process.

VII - CONCLUSIONS

The Lekin, is a recent program and although the version being tested was a demo, presented a very interesting graphical interface, allowing easy insertion of the configuration data. Also noteworthy in this application was the rapid completion optimizations calculus. An important aspect to report from this program is the possibility to creating a matrix setup for each machine. This feature is fundamental in this company in order to take into account the considerable amount of the operating time that is spent on machine setups, which is non-productive time and varies from product to product. This process will pose an excellent opportunity to create an accurate time base for all setups and retrieve reliable metrics for resource consumptions and waste evaluation.

Related with the application MASDScheGATS, although this tool is still in development, the algorithms employed have demonstrated good performance in different simulations, obtaining results very similar and better than Lekin.

As a final comment, with this work the company can obtain a more detailed assessment with regard to its production process and a better understanding of the actual times of the process according to the present range of products. This assessment is extremely valuable in order to the continuous evaluation of the sustainable metrics that the company intends to achieve. Also with this research work, it was possible to derive improvement recommendations to the company that resulted in a more efficient scheduling process for the critical operations, ultimately enhancing the company business sustainability.

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SOLAR MANAGEMENT COMPANY

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Abstract: An efficiency study was done on photovoltaic facilities in Porto, Santa Maria da Feira and Torres Novas which collected and inter-correlated data to show that shading is the most important factor to take care. Then a comparison between real values of energy produced and others simulated by PV*Sol allowed to know deviations and verify pay-back periods initially indicated to the owner of the PV facility. Finally an optimization of energy produced in PV systems changing tilt and azimuth was developed knowing real data climate. All these instruments together with a panel cleaning service are tools for a new business sustainability company with an interesting market that will contribute to a cleaner production of electricity and a lower CO_2 production.

Keywords: Technology, Management, Engineering, Energy.

INTRODUCTION

An efficiency study of photovoltaic systems was done with the help of a Portuguese Solar Company that allowed contact with their customers in Porto, Santa Maria da Feira and Torres Novas.

A fieldwork was elaborated to collect data from 9 photovoltaic systems such as geographical coordinates, number of modules, cell type, matrix type, distance between rows, azimuth, tilt, shading, surface temperatures, dirtiness, type of support panels, wiring lengths from panels to inverter and from inverter to counter, energy production.

All data were inter-correlated and shading was shown to be the most important factor to take care as it can be seen in Figure 1. The income losses from this factor reached a maximum of 18% (depending on operating conditions), which corresponded to a monetary loss of approximately 800 €/year [1].

ventilation and achieve higher energy efficiencies that can reach up to 5% year [1].

A comparison between real values of energy produced in the 9 PV systems and others simulated by PV*Sol allowed to know deviations and verify pay-back periods proposed to the clients. The majority 77% of simulated values were lower than real energy produced values with sum absolute energy deviations of about 55,9%. Due to this deviation the payback period estimated by the solar company was over estimated, with a value in average 5.6% higher [1].

The optimization of energy produced study based on real climate data allowed to know that a slight variation in the azimuth or tilt of the PV solar panels can allow the owner to have an increase in profit. During the period analyzed (under 9 months) three clients reached a value from 74 to 437 €/year year [1].

Matriz de correlação

rcrit (±): 0,378 Niv. Sig.: 0,1 Graus Lib: 18

	Inclinação (º)	Azimute (º)	latitude (º)	Idade (meses)	Comp. cablagem(inv.-cont.) (m)	Sombr.	Local geo.	Área (m2)	Produção (média diária -kWh)
Inclinação (º)	1								
Azimute (º)	0,142	1							
latitude (º)	-0,239	0,239	1						
Idade (meses)	-0,357	0,202	0,647	1					
Comp. cablagem(inv.-cont.) (m)	-0,035	0,192	-0,166	-0,203	1				
Sombr.	-0,097	0,005	0,483	0,741	-0,143	1			
Local geo.	0,037	-0,278	-0,931	-0,656	0,267	-0,48	1		
Área (m2)	0,148	-0,163	-0,558	-0,644	0,504	-0,518	0,591	1	
Produção (média diária -kWh)	0,284	-0,061	0,191	-0,365	-0,378	-0,436	-0,171	-0,037	1

Fig. 1 - Intercorrelation matrix

The type of support structure of the panels was another factor that reduce energy produced. Some structures have enough space for natural

A dust layer of one-seventh of an ounce per square yard decreases solar power conversion by 40% (said Malay K. Mazumder, a research professor in the Dept. of Electrical and Computer Engineering of Boston University). A solar panel cleaning service is a necessity to improve energy efficiency.

All the above knowledge gives instruments or tools for a new business sustainability company with an interesting market that will contribute to a cleaner production of electricity and a lower CO_2 production.

BUISINESS PLAN

Company Services

The company activities can include:

1. Project, install and maintenance of PV panels, thermal panels, solar water pump, PV street lights, solar road traffic lights, solar led lights for billboards, solar chargers (mobile, laptop, gps,…), solar torches, solar decoration lights.
2. Optimization of tilt and azimuth from any kind of solar panels in order to achieve an higher profit.
3. Simulation of solar panels more close to real or future facilities. Payback determination of the investment.
4. Solar panels cleaning

Real and Potential Market

In 26th of April 2010 there were in Portugal 50000 facilities with 175500 m^2 of installed thermal solar systems in private clients and 585 more with 25155 m^2 were already ordered to public institutions [2]. In the case of PV systems there were 6908 facilities corresponding to installation power of 26.7 MW at the same date [2]. National Energy agency believes in the next years that the solar market will increase 10 to 20%.

In Portugal public illumination corresponds to 3% of total electric consumption and in some municipalities it corresponds to more than 50% of total energy cost [3]. This is also a new market that the new solar management company would like to step into.

Marketing position

Solar energy is clean and solar maintenance gives profit.

Strategy

In the study done 77% of the simulations of energy produced (PV*Sol) in PV systems given by the installation company were underestimated, in average, 5.6%. It is known that a good panel cleaning service is able to improve efficiency at least in 10%. The optimization of tilt and azimuth of the panels can reach an improvement from 3,7% to 16.3%. All this improvements can reach an average margin of 25.6% extra energy produced, which corresponds to 689 €/year. The new solar company will charge 50% of this value for the cost of the service.

Parallel to this service, Solar Management Company intends to be able to sell, project and install any solar system with a small commercial margin.

Swot Analysis

Strength

- Capacity to do an optimization of azimuth and tilt of Solar panels taking into consideration real climate data.
- Chemical engineering knowledge to do the cleaning, understand the physic and chemistry phenomena and create strategies for energy optimization.

Weakness

- Make the owner of Solar panel understand the need and the margin of this service.

Opportunity

- 60000 solar facilities to improve.
- Portugal has high solar radiations (Faro 1,56, Lisboa 1,45, Porto 1,39 kWh/kWp).
- Solar devices specially PV systems for micro-producers are relative recent in Portugal (3,5 years maximum).
- There is a lack of knowledge in the maintenance and installation of solar facilities
- Economical and environment world crisis
- Actual National legislation promotes solar systems growth with subsidies and tax deductions

Threat

- Other solar companies doing cleaning services and selling and installing solar panels.

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MOTIVATIONS FOR CRM ADOPTION IN LARGE COMPANIES IN PORTUGAL

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Abstract: There are several reasons that may underlie the adoption of Customer Relationship Management (CRM) systems. Among the most common motivations there are the search for increased sales efficiency, costs reduction, improved customer service, increased business results, and others. This paper presents and discusses the results of a study that sought to identify the main motivations for the adoption of CRM systems by large Portuguese firms, and the main findings show that the companies invest in CRM by a wide set of reasons like, for instance, to improve the information quality, search for more effective sales/transactions, and improve the overall customer satisfaction.

Keywords: Motivations, CRM, adoption, large companies.

INTRODUCTION

CRM stands for Customer Relationship Management and is a combination of a business and marketing strategy that integrates people, process, technology and all business activities, with the purpose of to attract and retain customers, provide analytical capabilities, reduce costs and increase profitability, by the consolidation of the principles of customer loyalty [1]. CRM is based on Internet interaction between the customer and the service provider.

Over the last 15 years, CRM has developed into an area of major relevance [2], and despite significant interest from both academicians and practitioners, CRM remains a huge investment with little measured payback [3].

Gartner Inc. reported that the market for CRM software achieved a growth in 2007 of 23.1 percent, rising to a total of \$8.1 billion, and worldwide CRM market revenue totalled \$9.15 billion in 2008, a 12.5% increase from 2007 revenue [4]. Also in 2007 Forrester Research Inc. anticipated that revenues would continue to grow to \$11 billion in 2010 [5, 6]. However, on the other side, commercial market studies and literature refers the high failure rate of the CRM projects [7-9], which justifies more research in this area.

Since the transition from a transaction-based economy to a relationship-based economy, that businesses have changed from being product-driven to customer-driven [10]. In particular, as CRM is fostering the economy, the authors sought to better understand the phenomena of CRM systems adoption, and undertook a survey within a sample of large Portuguese enterprises. This study aimed at understanding which are the main motivations of large companies to adopt CRM systems.

This paper makes two contributions: (1) it allows the academic and professional community to better understand the main motivations of large companies for adopting CRM systems; and (2) it allows CRM systems vendors and consultants to better address the needs of their potential clients.

The next section frameworks the main concepts associated to CRM and CRM adoption, the third section introduces the methodology followed in the study, section four discusses the results, and the last section closes the paper with some conclusions and future research directions.

MOTIVATIONS FOR CRM ADOPTION

To operate in an e-Business environment, an organisation needs a good control of knowledge on its markets, customers, products and services, methods and processes, competitors, employee skills and its regulatory environment [11]. Findings of several studies, for instance [12-14], validate the belief that CRM is a critical success factor for business performance.

Given its major importance for business competitiveness over the last 15 years, literature is rich and many research projects have been and are being carried out to identify and understand the main motivations for CRM systems adoption, the difficulties occurred in its implementation, the obtained results, among many other aspects, aiming to improve the theory and practice of CRM planning and development.

This section presents several motivations for CRM systems adoption in an organization. Among the several potential motivations, a compilation of literature surveys [1, 9, 15-23] highlights the following aspects:

- To increase the companies' knowledge with respect to its customers, allowing the registration, maintenance and treatment of large volume of data concerning the customer and retrieval on real time, with the objective of keeping a differentiated and profitable relationship of the company with the customer, increasing customer retention and loyalty;
- To drive the company towards the market;
- To develop and offer customized products and services differentiated from products and services of concurrence, through the use of pre-defined modules or different combinations;
- To establish a close and systematic communication with actual and potential customers;
- To reduce the cost of sale and of after-sales service, increasing the effectiveness of a vendor in its role of acquiring new customers;
- To aggregate value for the client, rationalizing the internal processes of new product development, allowing the company to know the needs not addressed and the characteristics of the product desired by segments of customers, and administration of the flow of demands, reducing customer's buying time and psychical effort, optimizing after-sales service through the offer of specialized quality services.

In summary, the motivations for the involvement of an organization in planning inter-organizational systems can be summarized in five main groups: (1) information sharing, (2) increased productivity, (3) reduced costs, (4) higher determination, legal or normative and (5) strengthen the relationship with customers.

These aspects lead us naturally to one of the most important steps that is the ability to identify new products or services that may be of interest to the most profitable customers. To understand customers, anticipating their needs and offering value-added services is recognized to be determinant for organizations in their quest for success.

METHODOLOGY

In order to understand the main motivations for CRM adoption by large companies in Portugal, the authors carried out a study involving an online questionnaire, which call for response was sent via e-mail to a stratified random sample of 500 companies in the universe of the 1000 large national companies in terms of turnover, according to the Portuguese National Institute of Statistics (INE).

The questionnaire was made available on an online platform in the period from 09/Feb/2009 to 11/May/2009, and comprehended four rounds of response. It was structured by thematic groups of questions and included several types of questions (multiple choice, free text). It was pre-tested and underwent an iterative process of content and clarity validation to get the final version. There were obtained 85 valid responses, corresponding to a 17% response rate. After the data collection it was carried out a descriptive statistical analysis.

CHARACTERIZATION OF THE SAMPLE

The first group of questions in the questionnaire intend to characterize the companies participating in the study. The characterization of the companies is presented in Table 1. It is interesting to note that most companies have fewer than 2,000 employees and only 11% of the companies have more than 2,000 employees. In terms of turnover, companies are distributed across the intervals of Table 1. To note that a significant proportion of companies (44%) had a turnover of between 50 and 250 million Euros per year. The number of responses "Do not know / Do not answer" has a value of 12%.

Table 1. Characterization of participant companies.

Number of employees	Percentage
1 to 200	26%
201 to 500	31%
501 to 2000	32%
2001 to 5000	8%
More than 5000	3%
Turnover (euros)	**Percentage**
Less than 5 000 000	0%
5 000 000 to 10 000 000	1%
10 000 001 to 50 000 000	29%
50 000 001 to 250 000 000	44%
250 000 001 to 500 000 000	5%
More than 500 000 000	9%
Do not know / do not answer	12%

From the set of 85 valid responses, only 21 companies use CRM systems (25%). Its characterization is presented in Table 2. This a quite small percentage when compared with the results of other studies of adoption; for instance a survey made in 2008 in Austria reported that 38% of the surveyed enterprises do not use a CRM system [24].

Table 2. Characterization of companies using CRM systems.

Number of employees	Percentage
1 to 200	24%
201 to 500	32%
501 to 2000	29%
2001 to 5000	5%
More than 5000	10%
Turnover (euros)	**Percentage**
10 000 001 to 50 000 000	29%
50 000 001 to 250 000 000	42%
250 000 001 to 500 000 000	5%
More than 500 000 000	10%
Do not know / do not answer	14%

DISCUSSION OF RESULTS

Participants were inquired about the relevance given to a selection of motivations extracted from literature, in a scale from 0 (not important) to 5 (very important).

Table 3 presents the average and standard deviation obtained for each motivation included in the questionnaire and Figure 1 presents the ranking of the reasons for large companies to use CRM systems in terms of the average of the answers given by the participants that use CRM systems.

Table 3. Motivations for CRM adoption

Motivations	Average	Std. Dev
Improving the quality of information	3.857	1.0623
Search for more effective sales/ transactions	3.857	1.2762
Improving overall customer satisfaction	3.857	1.3148
Processes improvement	3.750	1.3328
Improving customer service	3.714	1.3093
Increase business results	3.667	1.3540
Customer loyalty	3.238	1.3750
Possibility of individualized marketing messages	3.000	1.7889
More effective customer acquisition	2.952	1.6272
Not to be outdone by competitors	2.667	1.5916
Implementing a new business model	2.619	1.6272
Cost reduction in sales	2.381	1.5961
Cost reduction in after-sale	2.381	1.8021
Creation of customized products and services	2.048	1.6875

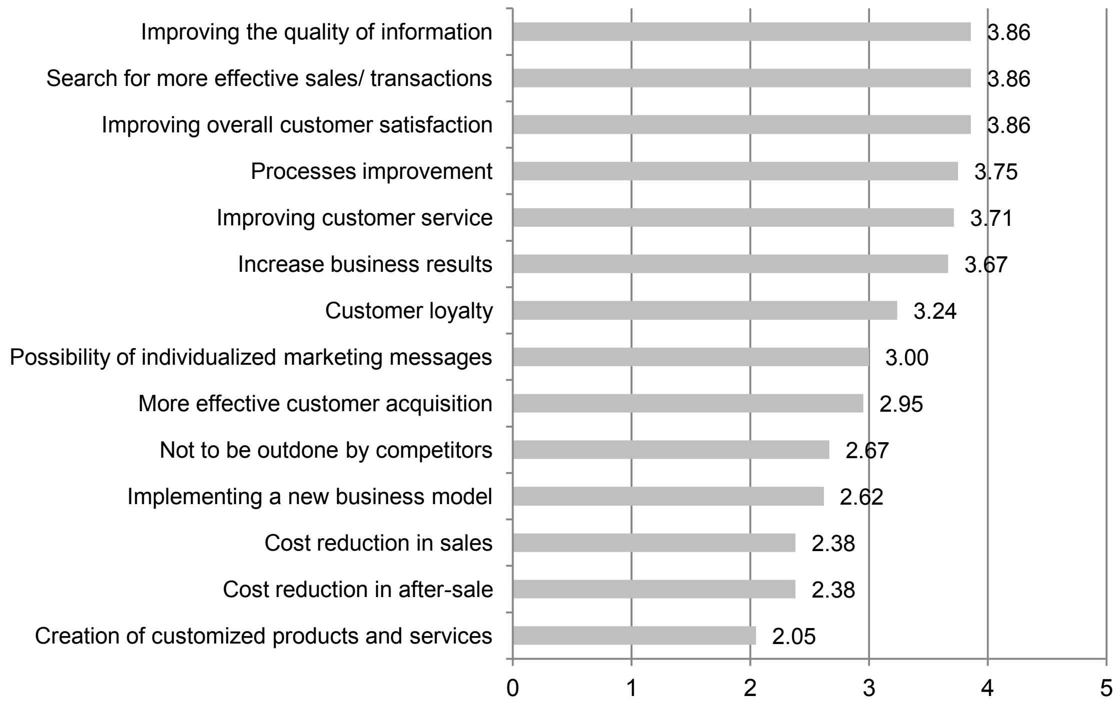

Fig. 1. Ranking of motivations for CRM adoption

In most companies are prevalent the motivations "Improving the quality of information", "Search for more effective sales/ transactions" and “Improving overall customer satisfaction”, closely followed by "Processes improvement“, “Improving customer service” and “Increase business results”. Financial motivations did not deserve the main position, which reinforces the interest in improving the services, processes, quality and client satisfaction.

The main finding is that there is a strong concern with satisfying customers’ needs, and these factors are indeed a strong motivation to implement CRM systems; it is interesting to note that the standard deviation shows quite unanimity of opinion in this sense.

It is possible to understand a larger dispersion of results concerning the motivation “Cost reduction in after-sale”, which means that although the mean value indicates that this factor is not a major motivation when compared with other factors, the standard deviation value shows that this item raises a relatively large motivation for adopting the CRM system for some companies.

CONCLUSIONS

The authors have undertaken a study directed to the largest Portuguese companies in terms of turnover, in order to perceive the motivations of companies towards the utilization of a CRM system. Of the 85 firms that responded, 25% (21 companies) affirmed using CRM systems, which is a very low rate given the importance that these systems may have in the development of the company competitiveness.

Within the set of motivations given by participants in the study, there were found six main motivations (above the average 3.6), mainly related with the improvement of the quality of information, the improvement of the services and the increase of business results.

One of the main limitations of the study is the reduced number of answers, only 21 of our inquired companies used CRM systems. A further research should be undertaken with a larger sample and an attempt to compare results with similar studies across the world should be tried.

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HOW TO REDUCE ENERGY CONSUMPTION ON PULTRUSION

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Abstract: The global warming due to high CO2 emission in the last years has made energy saving a global problem nowadays. However, manufacturing processes such as pultrusion necessarily needs heat for curing the resin. Then, the only option available is to apply all efforts to make the process even more efficient. Different heating systems have been used on pultrusion, however, the most widely used are the planar resistances. The main objective of this study is to develop another heating system and compares it with the former one. Thermography was used in spite of define the temperature profile along the die. FEA (finite element analysis) allows to understand how many energy is spend with the initial heating system. After this first approach, changes were done on the die in order to test the new heating system and to check possible quality problems on the product. Thus, this work allows to conclude that with the new heating system a significant reduction in the setup time is now possible and an energy reduction of about 57% was achieved.

Keywords: Pultrusion dies, FEA Simulation, Heating Systems, Energy

INTRODUCTION

Nowadays, continuous improvement can be a constant concern on management requirements. Save energy contributes to reduce pollution related with its production because only a small portion of energy is ‘green’ (generated by renewable means). Sustainability business need that managers can be alert for all the factors that can contribute to increased competitiveness.

Pultrusion is a continuous process employed worldwide to manufacture profiles with constant cross section in polymeric composite [1 - 4]. This material, constituted by thermoplastic or thermosetting resin matrix and glass fiber reinforcement, is usually called as glass fibers reinforced plastic (GFRP) composite [5]. Pultruded products are based on long glass fibers (known as roving) impregnated in a thermosetting resin matrix that are molded by a tool die, which provides the necessary heat to carry out the cure of the matrix. These products are used in structural applications when high specific mechanical strength and good chemical resistance are needed [6]. In order to produce products by pultrusion, electrical energy is mandatory in order to induce chemical reactions for polymerization.

Simple observation of the systems used to heat the die stimulated studies in order to reduce the energy lost in the process. This reduction can decrease the cost production, increasing the competitiveness and to contribute to reduce both pollution and global warm.

The graphics shown in Figure 1 compare the GFRP properties with three others materials commonly used in mechanical manufacturing. Analyzing Figure 1, it is possible to conclude that among the materials presented, GRFP always present better characteristics, combining a high specific mechanical strength with low linear expansion [7]. This material can achieve results as being 4 times lighter than steel and 2/3 than aluminum, still having advantage on strength/weight ratio [6].

Beyond the light weight of the GFRP there is a strong competitive advantage: easy transportation of structures, extremely important in specific situations. Assembly operations with these materials can be done using rivets, adhesives and screws, among others. Furthermore, the usage of these materials in high corrosive environments allows to achieve a long durability due to their good chemical resistance.

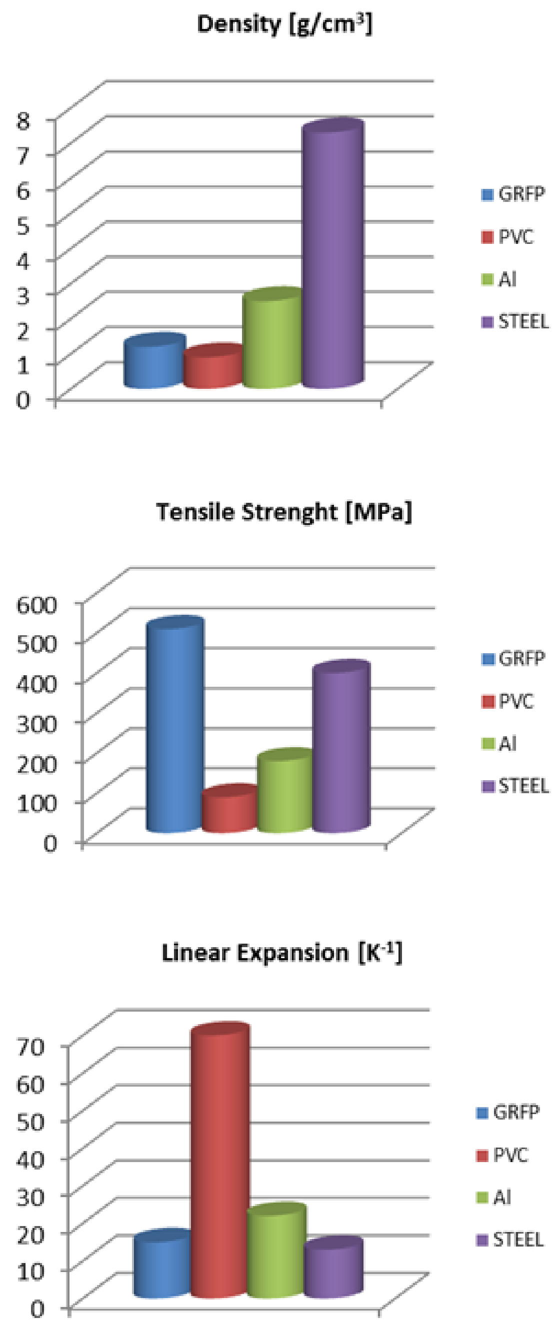

Fig. 1 - Comparative properties of the GFRP with other materials intensively used in structural applications.

The main advantages of pultrusion process are related with low labor requirements and simplicity of tooling. In order to better adequate the product to the final application, appropriate set of materials and parameters must be selected. Composites can be reinforced with unidirectional fibers, mat and woven. The usage of surfacing veils must be taken into account if surface quality is required [8].

Epoxy, polyester and vinyl esters are the most commonly used resins. Their usage depends on the final application.

Additives like catalytic and accelerator need to be added to the resin, in right proportions, with the scope of improving the pultrusion process as well as others, like fire retardants, intended to increase the safety of the product.

In this process, a dual traction system is responsible for the composite pulling. The dual traction system allows a continuous pulling of the GFRP through the die [1, 5].

The pulling speed must respect some conditions like the bar thickness, die length, die temperature and resin formulation. With all this conditions to match, is possible to realize that empirical knowledge is fundamental to achieve the optimal speed with high quality standards. At the end of the process, the pultruded composite is automatically cut in the necessary length dimensions [1-3].

Generally, the efficiency of the heating system is not a key factor for pultrusion manufactures. This fact is supported by the widespread usage of externals heating systems [9-10] which is associated with significant losses of heat.

However, essentially due to environmental issues, it is imperative to develop more efficient heating systems where it will be possible to combine a lower manufacturing cost with ecological concerns.

These systems have low setup times, however high heating losses are a reality. Thus, other systems have already been presented to solve this problem, such as fluid circulation and electrical cartridges heaters. This study is developed based electrical cartridges because this heating system increases energy saving, allows temperature refinement in different zones along the die and decrease the setup time.

This work has a strong support in finite element analysis, like others researches [9-13], in order to avoid expensive costs. In spite of prepare and validate FEA studies, thermographic technology was used. After a previous analysis of the initial heating system by thermography, simulations were done in order to analyze and optimize the heating system, using cartridge embedded resistances, keeping the temperature profile similar with the former one.

EXPERIMENTAL

The pultrusion system layout can be observed in Figure 2.

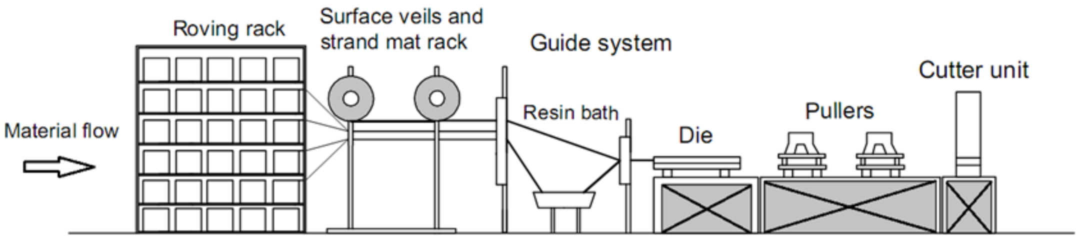

Fig. 2 - Pultrusion layout.

In Figure 3 is shown the die tool and the planar heating system.

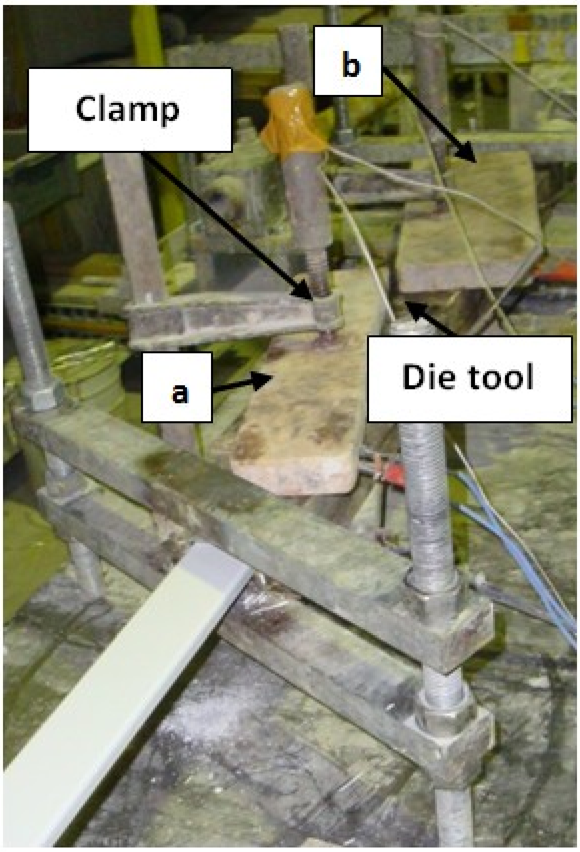

Fig. 3 - Initial set-up die with 800W plane heaters: (a) small and (b) large electrical resistance.

Thermographic measures were done in order to match experimental results with the simulation ones. These pictures were taken during stable manufacturing regime, allowing to obtain the temperature profile along the die. Each image was divided in 100 different areas corresponding to a matrix of 4 lines in height and 25 in width, considering the lateral surface of the die, as represented in Figure 4.

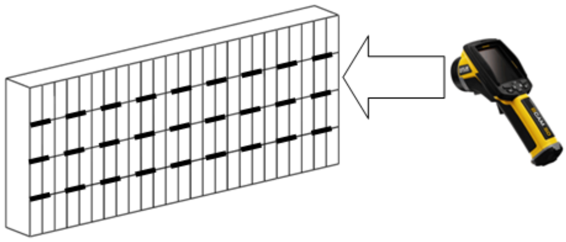

Fig. 4 - Schematic representation of all the points considered on the lateral wall of the die when analyzed by thermography.

Following each session, images are analyzed, determining temperatures in the points corresponding to the cross of the horizontal dashed lines with the vertical ones in Figure 4. After analyzed all the images, statistical tools were applied resulting in a temperature profile along the die used as referential for further developments.

In order to compute by FEA (Finite Element Analyses) the present case, SolidWorks® software was used to modulate the die tool/heaters system. To perform the FEA, appropriate simulation software was used. This case is considered as in transient thermal state and the following assumptions were made: all contacts were considered perfect, all the bodies are initially at room temperature of 22°C, and considered remaining constant at this temperature, convection coefficient is 2W/m2.°C and emissivity is 0,8.

There was considered a ΔT = ±5°C usually used by this manufacture for this “U” profile. This simulation was performed for a period of 4500 seconds. A period of 3600 seconds was verified to warm up and other one of 900 seconds was simulated, considering this time as a representative period that will be repeated along the working day.

After this analysis, another heating system with eight cylindrical heaters embedded on the die, previously presented by Sumerak [10] was applied and studied in this case. Globally, the power used to heat the die tool is the same because each cylindrical heater has 400W. The study of this system aims to reduce the set-up time and improve the thermal efficiency.

The layout of the resistances along the die shown in Figure 5.

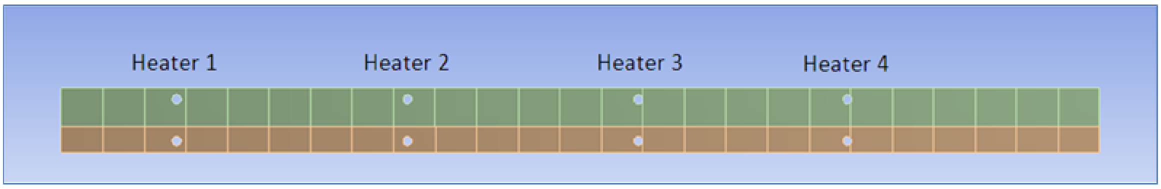

Fig. 5 - Location scheme of the resistances pairs with temperature probes

The new system had been simulated with the same assumptions as the previous one and was considered ΔT = ±5°C. This simulation followed the same temperature profile drawn by thermography.

RESULTS AND DISCUSSION

In Figure 6 is shown a thermographic picture and its corresponding analysis. Here is possible to see the temperature in each selected point. Then, the results of all the images have been average in order to obtain the temperature profile along the die shown in Figure 7.

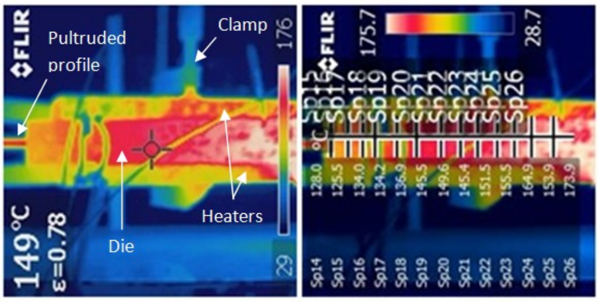

Fig. 6 - Thermographic images with and without analysis

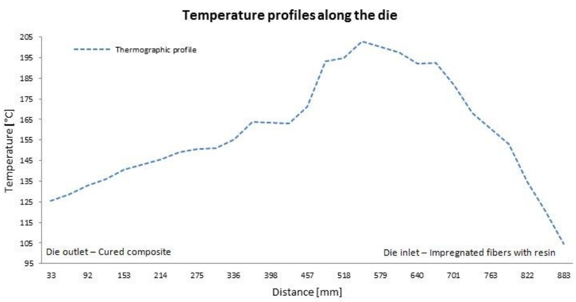

Fig. 7 - Temperature profile along the die obtained by thermographic studies.

At the end of the simulation, two different approaches were done. First, the verification of matching between the temperature profile drawn by thermography and the one obtained by the FEA was made, as shown in Figure 8. The maximum deviation obtained is 7%, which is considered acceptable for this analysis. In right side of this figure, a large mismatch between curves can be observed, however, this fact is due to operational reasons. Following correct procedures of thermographic measures, this part of the die tool is behind fastening elements that are used to fix the die to the pultrusion equipment, blocking the infra-red beam of the camera.

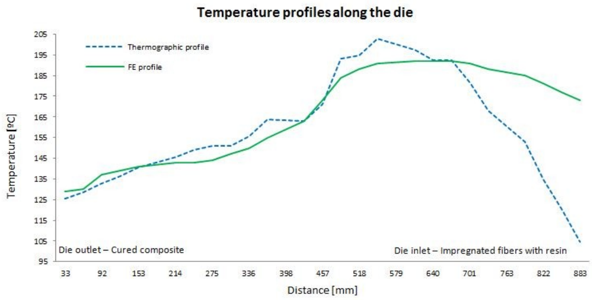

Fig. 8 - Matching between thermographic temperature profile and simulation one.

Then, a study related with the power used by the heaters during a complete working day has been realized and it's shown in Table 1.

Table 1 – Detailed power consumption of planar heaters.

Planar heaters			
	Warm up (1h) [kWh]	Manufacturing (7h) [kWh]	Subtotal working time (8h) [kWh]
Small heaters	0,660	0,192	2,0
Large heaters	1,412	0,948	8,0
Total power consumption per manufacturing day [kWh]			10,0
Total power consumption per manufacturing month (22 days) [kWh]			221,1

Concluded the FEA simulation considering the cylindrical heaters, Table 2 was done in order to better compare the results between these two systems. In this table, heating system 1 and 2 of Figure 5 present their working time together to compare it with the heating system “a” of Figure 3, and heating system 3 and 4 of Figure 5 show results together to be compared with heating system “b” of Figure 3.

Table 2 - Resumed results of power consumption for the cylindrical heating system.

Cylindrical heaters			
	Warm up (0,5h) [kWh]	Manufacturing (7,5h) [kWh]	Subtotal working time (8h) [kWh]
Heating system 1 and 2	0,569	0,092	0,975
Heating system 3 and 4	0,981	0,385	3,377
Total power consumption per manufacturing day [kWh]			4,352
Total power consumption per manufacturing month (22 days) [kWh]			95,744

Comparing the data of the Table 1 and Table 2, is possible to analyze the difference between the two heating systems, as shown in Table 3.

Table 3 - Results comparison between planar heaters and cylindrical ones.

Planar heaters - Power consumption per manufacturing day [kWh]	10,048
Cylindrical heaters – Power consumption per manufacturing day [kWh]	4,35
Reduction [%]	-56,7%

The reduction is about 57% using this new system, which is a significant value. Figure 9 shows the same part of the die tool heated by the two different systems; "A" corresponds to the planar heater and "B" to the cylindrical ones. As is possible to check, besides being more efficient, this system promotes a homogeneous heat flow and a better control of the temperature for each zone of the die, which isn't verified with the planar heaters.

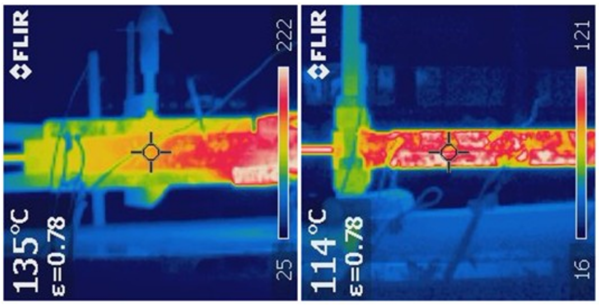

Fig. 9 - Thermographic images showing the differences of homogeneity of temperature. A - planar heaters. B - cylindrical heaters

CONCLUSIONS

The main goal of this work is to improve energy consumption, reducing it, studying a more efficient heating system used on the pultrusion process. Thus, the following conclusion can be drawn:

- No differences between new heating system and former one were detected;
- Power consumption decreases 57% using the embedded cylindrical heaters instead the initial system;
- The warm-up time was reduced up to 50%, improving the set-up time and increasing the production time;
- Temperature control is more specific due to the increase of temperature probes, allowing better refinements if necessary;
- No production defects were detected using the new heating system;
- Pultrusion can be more efficient using this new heating system, more environment friendly, competitive and flexible;
- New production economical quantities can be computed due to the setup time reduction achieved with this work.

Moreover, this new heating system was tested during manufacturing, exhibiting high quality standards without manufacturing problems. Thus, this system is highly suggested with the purpose of increase productivity, keep high quality of pultruded products and reducing the setup and warm-up times as well as energy needs.

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OPTIMIZATION OF THE PULTRUSION PROCESS

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Abstract: Manufacturing processes need permanently to innovate and optimize because any can be susceptible to continuous improvement. Innovation and commitment to the development of these new solutions resulting from existing expertise and the continuing need to increase productivity, flexibility and ensuring the necessary quality of the manufactured products.

To increase flexibility, it is necessary to significantly reduce set-up times and lead time in order to ensure the delivery of products ever faster. This objective can be achieved through a normalization of the pultrusion line elements. Implicitly, there is an increase of productivity by this way.

This work is intended to optimize the pultrusion process of structural profiles. We consider all elements of the system from the storehouse of the fibers (rack) to the pultrusion die. Particular attention was devoted to (a) the guidance system of the fibers and webs, (b) the resin container where the fibers are impregnated, (c) standard plates positioning of the fibers towards the entrance to the spinneret and also (d) reviewed the whole process of assembling and fixing the die as well as its the heating system.

With the implementation of these new systems was achieved a significant saving of time set-up and were clearly reduced the unit costs of production. Quality assurance was also increased.

Keywords: Pultrusion, lead-time and set-up optimization, fiber glass

1. INTRODUCTION

Pultrusion is a process to obtain continuous profiles [1 2] in fiber reinforced polymer. The association of these materials, matrix and reinforcement, is called composite and consists on the combination of two or more distinct materials improving their properties when combined Figure 1 [3].

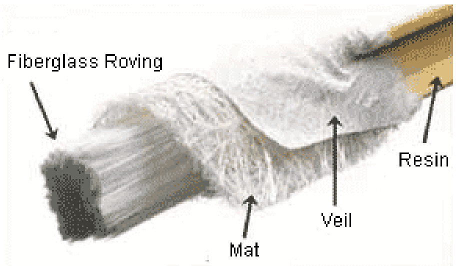

Fig. 1 - Scheme of a pultruded profile [Adapted from http://www.aojintl.com]

To the production of these profiles can be used fiber glass, carbon, aramid or boron as reinforcement. However, the most used in this process is the fiberglass type E [3]. The focus on process is characterized by a low manpower use and high efficiency of the conventional raw materials in order to obtain the desired shape. Pultrusion is also characterized as a low-cost process [24].

The fibers, in the wire form (Roving), are placed in appropriate locations shelves (Rack) and depending on the number of wires used to design the profile is used more or less racks because each is limited by the roving number. To obtain high performance pultruded products, is placed along with the roving, mat or cloth depending on the application and strength employed. These reinforcements are collimated to enter the die, however it is necessary to saturate them previously with resin. During the impregnating process, the roving passes through holes made on plates of polytetrafluoroethylene (PTFE) [4] which guide the wires from the racks to the die entrance, which is also soaked in the tub. The use of PTFE is due to its lubricating properties and no abrasivity to the fiber, is a substance practically inert, not reacting with other chemicals, not deteriorating with the resin or other liquid during the cleaning operation. Some of these plates are attached to a metal rod called fork dipping in the tub containing the resin with their compositions upon the desired effect. In this case was used thermosetting resin, however the pultrusion process can be accomplished with a thermoplastic resin and the processing done otherwise.

After the fibers are fully impregnated by passing the guidance system for each individual profile, they approaching gradually the intended manner, thus preventing the fibers break when entering into the die.

In order to the process take place, it needs a monitored system of trailing (pullers), with their speed controlled and movement synchronized, avoiding possible breakdowns and defects on the profile. The speed and traction force are determined by the coefficient of friction between the mold walls and the composite as solid [5]. This velocity is also influenced by the resin type, thickness and complexity of the profile [4].

Upon entry of the impregnated fibers in the die, begins the process of profile forming and resin polymerization (when the mixture of two or three components of resin, catalyst and accelerator is held in proper proportions) [3], which is due to reaction with the die temperature. Resin reacts with the catalyst releasing energy to this event calls itself exothermic [2], passing through three stages: liquid, gel and solid [6], which is difficult to control. However, sensors are placed temperature along the die [7] that when it reaches a certain temperature switch off the resistance do not exceeding the expected temperature.

At the end of the process there is a cutting system that works in a sync movement with the pullers in order to cut the profile through the length you want without making stops in the pultrusion machine. The pultrusion entire system is show schematically in Figure 2.

2. EXPERIMENTAL

The machine analyzed in this work presents an excessive setup time due to the preparation of all the devices linked with the pultrusion machine. In fact, each time that the profile in production needs to change, it is necessary to change the number and location of the fibers and webs in the feeding rack, to adjust the fibers guide system, to pass the fibers through the resin into the container, to fix the mandrel (if needed), to assemble, adjust and calibrate the die, and to adjust and synchronize the puller and cutting disk [1, 2, 8].

Analyzing all the system, some devices were identified with potentially upgradeable in order to decrease the setup time and optimize the energy consumption. Thus, the fibers guiding system, container, fibers positioning system close to the die entrance, fastening procedures of the die, die heating system and pullers seem to be capable of improvements.

The pultrusion line used for this work is shown in the Figure 3.

Fig. 2 - Initial pultrusion line layout (excluding the puller system)

Then, the different sub-systems will be presented in order to the initial situation and all the changes recommended and implemented.

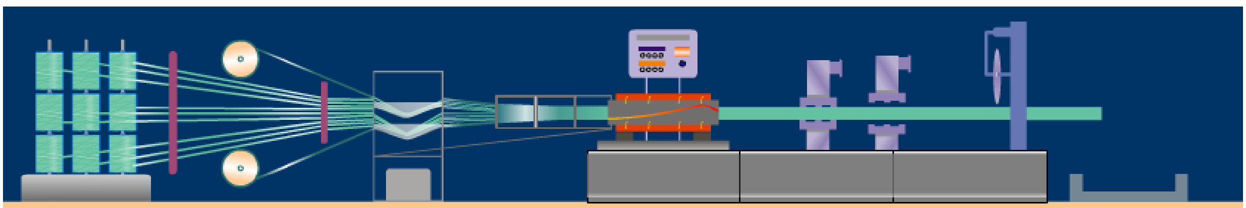

Fig. 3 - Schematic representation of the pultrusion line [Adapted from www.topglass.it]

2.1 Fibers and webs guidance system

At the beginning of the process, the fibers in the form of roving are placed on racks to be processed. For that happens, these fibers have a way of 5 to 10 meters and it is necessary to keep all the fibers in their right positions without leave or cross them, because this introduce defects on the quality of profiles. The initial guidance system can be seen in the Figure 4 and 5. Thus to avoid these intersections of fiber was drawn and has been made a support that would allow placing a plate with holes so that the fibers flow and be correctly guided. Then there is a variety of supports to put cloth or blanket as needed for profile allow to center without them slipping.

Fig. 4 - Initial fibers guidance system

Fig. 5 – Initial webs guidance system before resin impregnation

2.2 Resin Container

On this stage, fiber needs to be conducted to the resin bath, which can be at a constant temperature, independently of the room temperature. In spite of immerse the fibers into the bath, a fork system forces the fibers to pass throughout the resin. After this, fibers are impregnated with resin and the excess is being drained when they move away towards the fiber positioning system.

To keep the temperature constant into the container is a complex task because the heat exchange is continuous: resin is in contact with the air, resin and additives are constantly added at the bath and the fibers constantly removes resin from the container. The initial resin container can be seen in Figure 6 and there is no temperature control at this stage.

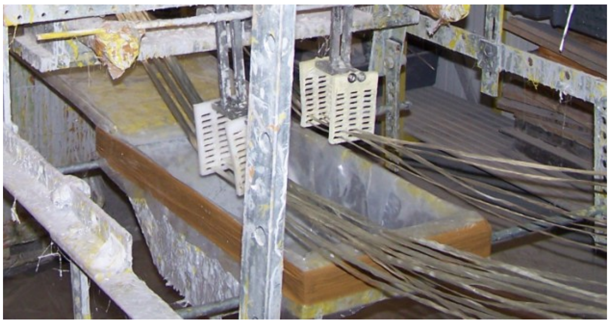

Fig. 6 - Initial resin container provided with respective forks

2.3 Guiding Plates

At this stage of the process the fibers (roving) are already impregnated from the resin bath and progressively guided through the guiding plates closer to the desired shape of the profile. Concerning to prevent the fibers breaking, several bars ensure the correct positioning of the wet fibers and webs towards the die entrance, as depicted in the Figure 7. If woven or mat is needed, they are saturated before entering in the die passing through the resin container or impregnated using pumps or auxiliary insert resin container in top, dropping resin over the mat.

Fig. 7 – (a) Initial guiding system after impregnation and (b) auxiliary impregnation of the mat

These guiding plates must be easy to place in order to avoid unnecessary loss of time and also to know where the fibers pass into holes of a particular profile. Each profile must have specific plates with only one operation tight in place, and only then need to run wires through the holes.

2.4 Mounting and fixing the die

Currently the die is fixed as depicted in Figure 8 The centering process is made manually using metric scales and the fixing system by clamps requires spending considerable time in order to assemble the upper and lower parts of the die, because the weight of the set is significant. Furthermore, required parameters are not guaranteed because alignment is not ensured one hundred percent. The heaters can also to be positioned under and over the die, depending on the profile. In this case, clamps are also used to ensure the accurate contact between die and heaters.

Fig. 8 – Fixing system of the assembled die

2.5 Heating System plates

The most widely used system for the efficient heating of the die consists of boards with embedded resistors, which are placed at the top and bottom [9].

The material of these plates should conduct appropriately the heat promoting quick exchange between die and heaters. This temperature is crucial for the resin cure or polymerization [8 6 10 11]. The temperature is controlled by sensors located along the die. This data is send to a control panel that allow to observe and edit the temperature in each region of the die, allowing a accurate control of the temperature profile for each product manufactured. Exothermic reactions happens during the polymerization process conducting to a peak exotherm temperature located approximately 60% after the die entrance [4, 2] which can be take into account by the heating system. Thus, the sensors control the temperature avoiding overheating of the profiles increasing the quality and reducing the non-conform products.

Fig. 9 - Heaters positioned in the die

Observing some old literature, the heating system selected was cartridge resistances provided with thermocouples embedded into the die. Initially, this solution seems to be more efficient than the former one because all the energy is used to heat the die and it is transferred across the surrounding area. Another advantage of this kind of heating system is the assembly time, reducing significantly the setup time.

3. DEVELOPMENTS, DRAWINGS AND RESULTS

One of the main goals of this work was to reduce substantially the lead time, decreasing the time needed to assemble the different components used in the manufacturing process in analysis. After local observations, workers spend a lot of time to change all the webs and mats used for each kind of pultruded product. Moreover, the support system is complex, not ergonomic and containing health risks. Furthermore, the existent system did not allow to use it with the flexibility required. Thus, a new support system was drawn, allowing high flexibility and mechanical stability, reduced change times and lower health risks. The new support is provided with several quadrangular holes where vertical structural bars can be assembled. In these bars, provided with holes, can be assembled cylindrical bars provided with conical supports that runs along them and can be blocked with a fast clamp. This structure is provided with fastening connections easy to get off and reassembly. The time to put the robing in the place is very low and another vantage is that the rolls of mat are always center with the die. The new system was drawn, produced and implemented, showing that the original idea works, reducing drastically the setup time in this task.

Figure 10 shows the initial draw and the system already implemented.

Fig. 10 - (a) Initial draw and (b) the system already implemented

The support for the resin bath was also improved using a similar support like mats and roving. This support will carry with both resin bath and forks to conduct the mat through the resin bath Figure 11. Furthermore, a new temperature controller for the resin container was developed in order to keep the temperature constant into the resin bath, independently of the room temperature. This system will be able to heat or cooling the bath as to be needed. Water circulation will be carried out in order to increase or decrease the temperature on the container by thermal transfer method using copper tubes. All this system will be thermally isolated, in order to avoid temperature transfers with the surrounding environment.

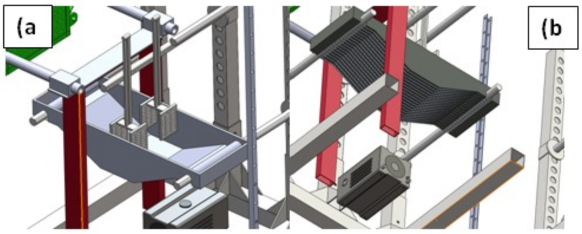

Fig. 11 – (a) New resin container without temperature conditioning system and (b) the container support integrated in the first structure developed

Each profile engages a different roving distribution. Thus, it is necessary a system constituted by a serial of PTFE plates provided with a hole matrix that supports the roving after it to leave the resin bath until it comes to the die entrance, as showed in Figure 12.

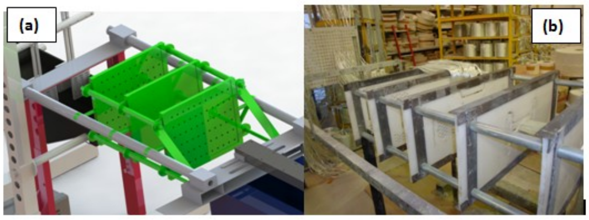

Fig. 12 - Guiding System: (a) – modeling (b) – real structure

The holes are strategically positioned for the fibers passing. Furthermore, the holes are labeled with the purpose of to facilitate the workers setup task and reduce the mistakes. It can be considered that each profile can be constituted by more than one hundred of single fiber strings which can take more than two hours to carry out. With this labeled system, the lead-time was reduced in 30 min.

The total lead-time was also cut due to the embedded resistances (Figure 13), which constituted an important improvement, leading a lead time reduction of 30 minutes relatively to the initial system. Both the time that the resistances remain turn on and the time that the resistances need to reach the warm temperature is lesser.

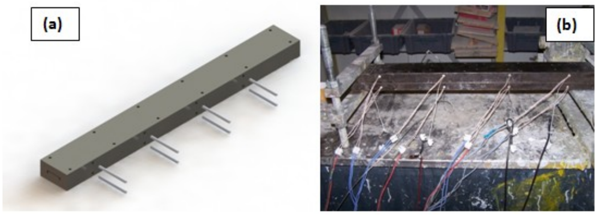

Fig. 13 - Heaters inside the die: (a) – modeling (b) – real structure

Thus, after the implementation of these improvements (some of them already applied) the pultrusion line must present a significant decrease of the set-up time (about 80 minutes), the thermal efficiency was already largely increased, the risks of mistake can be drastically reduced (about 70%) and the ergonomy will be improved, making the setup task easy for the workers. The complete system is illustrated in Figure 14.

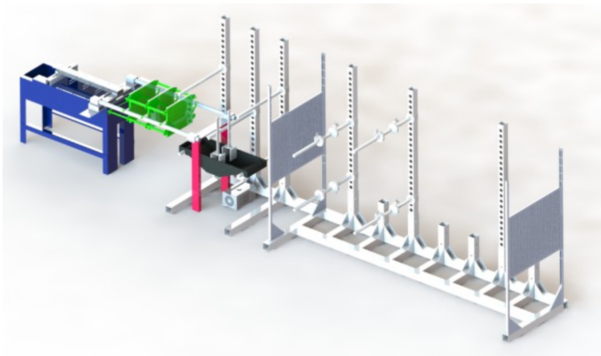

Fig. 14 - Pultrusion line after the planned improvements

REMARKS

This pultrusion line was largely improved in order to increase the simplicity and to reduce the lead and set-up times, attending that:

- The roving and mat support was redesigned leading to a better ergonomic work position and reduced set-up time. This structure allows to change roving and mat easily and is extremely flexible. Furthermore, it is easy to adapt it to new support configurations if needed (to add new mat rolls, and so on);

- The temperature of the resin bath will be controlled using a system constituted by some copper tubes where water circulation occurs that come from a water temperature conditioning, warm or cooling the resin as necessary;
- The roving guiding system was reviewed in order to clarify this task, avoiding risks and simplifying the set-up in this stage. Guiding plates will be labeled in matrix and the work preparation must establish how many fiber strings could be used and where they could pass on each table. Mistakes and cross linked fibers will be reduced in this stage;
- Attending the die, new heaters system allows to reduce the set-up and lead time, due to easily assembly task and the heat reaches the die cavity faster;
- The expectation of total time reduced on set-up is about 80 minutes: 20 minutes on the roving and mat support, 30 minutes on the guiding plate system and 30 minutes on the die cartridge. This represents a reducing of about 15% on the set-up time;
- The amount of wasted profile will be reduced 70% (expectation).

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COMPARATIVE STUDIES ABOUT PROPERTIES OF SOME AUSTENITIC AND FERRITIC STAINLESS STEEL GRADES

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Abstract: Rough materials cost has been increased consistently during the last years. Some stainless steels grades are strongly dependent on the nickel cost. Steel makers tend to diversify its offer, trying to maintain their costumers' competitiveness. In spite of this, some ferritic stainless steel grades tend to replace austenitic ones, reducing the production cost. However, ferritic stainless steel can be an option, depending on the applications. Attending to some market specific applications, mechanical and corrosion resistance tests were done in order to verify if ferritic grades can be used indistinctly replacing some austenitic grades or not. In this work, some well-established austenitic stainless steel grades, as AISI 201 and AISI 304L, were compared with ferritic AISI 441 stainless steel. Laboratorial and industrial tests were carried out in order to understand both the main differences and also what should change on setting parameters in order to adapt the mechanical deformation processes to the new ferritic grade. Obtained results allow us to state that some austenitic grades can be easily replaced by the new ferritic AISI 441 grade, despite some specific manufacturing parameters that should be adapted. A significant reduction cost should be achieved in some products, avoiding to reflect in the final costumer the increased cost of some rough materials.

Keywords: Recyclability, Corrosion resistance, Durable materials, Sustainable business

1. INTRODUCTION

Stainless steel is widely used in cookware, cutlery, and kitchen utensils. These are along with hardware supplies, industrial machines and equipment, structural buildings, automotive, train and aerospace industries. Because of its strong resistance to corrosion, is also largely employed for production of storage tanks and food containers. Otherwise, medical equipment production also makes use of stainless steel because it can be steamed and sterilized over and over. It is also a widespread material applied in jewelries and watches creation. Stainless steel applications increased drastically in the last years due to its durability and recyclability, allowing to reduce the natural resources consumption – an important environmental concern nowadays.

The reason behind its popularity is the range of its unique properties such as high mechanical strength and toughness, deftness to plastic deformation (cutting, bending, drawing and so on), good weldability and the possibility of being recyclable. However, the undoubted most important property of stainless steel is its ability to maintain the same surface, color and structure, i.e., its corrosion resistance. Stainless steel is one of the most durable steel which comes with an elegant natural finish. Chemical composition can be manipulated in order to achieve the best properties for each kind of application. Because of its qualities, it is one of the most cost effective materials for several applications.

Despite of this, the cost of some rough materials, as Nickel, used on austenitic stainless steel productions was drastically increased in the last years. Thus, some current applications were affected and the market is looking for other stainless steel grades, less expensive, that present similar properties and finish surface. Ferritic grades are a possible solution attending some applications where mechanical properties and corrosion resistance requirements are not very exigent. However, little information specifically dedicated to ferritic grades is available in the literature whereas austenitic grades are much more covered [1–4]. In fact, ferritic grades present lower Ni contents, which is a nice factor attending to its cost, and exhibit interesting mechanical properties and good corrosion resistance. However, some technological properties related with its transformation are well known. The ferritic stainless steel (FSS) sheet containing 11–17% Cr is known to develop an undesirable surface corrugation known as ridging when pulled or deep drawn [5], showing undulations, with peaks on one side of the sheet coinciding with valleys on the other side without changes in thickness. The ridges have a depth in the range of 20–50 µm. Causes of ridging, studied over the last three decades, can be attributed to the segregation of some alloying elements such as Chromium, Molybdenum or Carbon [6, 7]. These undesirable surface defects oblige manufacturers to add costs in polishing operation. Then, the effective advantage of these stainless steel grades seems lower when surface aspect is a crucial issue for the product.

Other problem attributed to ferritic stainless steels is sensitization, which occurs because of the formation of either chromium carbides or nitrides at grain boundaries [8]. Their formation leaves a zone depleted of chromium around the carbides that makes the steel susceptible to intergranular corrosion [9]. There are two main ways of reducing the risk of corrosion. Low carbon levels delay sensitization but do not prevent it. The other way is to add alloy elements to the steel,which are strong carbide-forming elements including Ti, Nb,Zr and V. The elements that have been found to be most useful are Ti and Nb [10, 11]. When only Ti is added, the steel has undergone single stabilization; when both Ti and Nb are added, the steel has been dual stabilized. Many researchers have studied the corrosion behavior of ferritic stainless steel [12–15]. However, researchers seldom have talked about the relation of texture and grain boundary character distribution (GBCD) of ferritic stainless steel.

However, other ferritic grades had been developed recently with the main objective of replacing some austenitic stainless steel grades with success. Ferritic stainless steels (such as 1.4003 chromium weldable stainless steel usually known as 3Cr12) are emerging as interesting and cost-saving alternatives to austenitic grades (304, 316L) or even more expensive materials in many applications, as referred by Rossi [16]. This material is designed to be employed in automotive exhaust systems, automotive trim, hot water tanks, fuel lines, cooking utensils, structural parts in bus coach structures or eventually in architectural members carrying loads [17].

This work was focused on AISI 441 ferritic stainless steel which was compared with two different austenitic stainless steel worldwide used (AISI 304L and AISI 201), evaluating its mechanical and technological properties, as well as its corrosion resistance. AISI 441 presented good mechanical properties and elevated corrosion resistance but some technological problems were detected when large deformation ratios on deep drawing process are required. This work intends to allow industrial managers to decide if AISI 441 stainless steel ferritic grades can be a good choice for the products that they manufacture, allowing the reduction of costs and keeping high the costumer expectations about stainless steel goods.

2. EXPERIMENTAL

The flat samples of austenitic AISI 201 and AISI 304L stainless steel and a ferriticAISI 441 stainless steel grade used in this work had been produced from sheet stainless steel specimens of 2mm thickness. In order to carry out mechanical tests, samples with 250mm x 25mm were cut in a shear sheet metal machine. In order to avoid the cutting edge deformation, samples were machined by milling, remaining with the dimensions of 250mm x 20mm x 2mm. The chemical composition of the stainless steels used is shown in the table 1. As can be seen in this table, Ferritic AISI 441 grade presents Ti and Nb in its composition, which stabilizes its behavior when submitted to certain kinds of corrosive environments.

Table 1 — Stainless steel chemical composition (%wt)

	C	Si	Mn	P	S	Cr	Ni	N	Ti	Nb
AISI 201	0.04	0.36	6.81	0.036	0.002	17.4	4.4	0.204	---	---
AISI 304L	0.025	0.39	1.77	0.030	0.002	18.2	8.1	0.050	---	---
AISI 441	0.012	0.5	0.49	0.028	0.020	17.9	0.4	---	0.11	0.42

With the aim of performing tensile tests, a SHIMADZU 100kN AutoGraph AG-X Series Universal Testing Machine was used, provided with clip gauge extensometer with l_0=50mm (used only in the first step of the tensile test) and a lateral clamp extensometer in order to evaluate the Poisson ratio. TRAPEZIUM X software was used in order to collect and compute the data, providing a general report. Tensile tests were performed following the NP EN 10002 – 1:2006 standard. The speed selected for this test was 2mm/min and the tests were carried out with 22ºC room temperature and 58% of relative humidity. Three different tests were performed for each material in order to verify the results accuracy and determine the standard deviation. These tests allowed drawing Force-elongation curves, let to obtain mechanical properties as Young's Modulus, Yield Strength, Ultimate Tensile Strength, Strain and Poisson's Coefficient.

This equipment was also used to make some load-unload tests in order to evaluate the hardening effect caused by repetitive mechanical work. These tests were carried out under the same condition of the tensile tests mentioned above but, each sample was carried until obtaining

8mm displacement. Thus, the sample was unload until obtaining 3 to 6mm displacement (sample presents plastic deformation in this stage). The load-unload cycle was repeated four times and the evolution of the force needed to obtain the maximum displacement considered (Δl = 8mm) was registered.

Surface fracture resulting of the tensile tests was analyzed by optical microscopy using an OLYMPUS microscope provided with a CANON digital camera and an image recording system.

In order to measure the hardness of each sample, an EMCO M4U Universal Hardness Tests was used, provided with a Vickers indenter. The maximum load used in these tests was 30kgf and the remaining time at the maximum load was 5 seconds. Hardness tests were carried out following the ISO 6507 - 1: 2005 standards. Attending that the samples were produced from a rolled sheet, the hardness tests were carried out under two different directions: perpendicularly to the rolling surface and on the machined lateral surface, corresponding to the nucleus of the rolled sheet.

Some samples of each material were bended under two different shapes: the first one following an internal radius of 20mm and the second one making an acute angle of 30º, being completely closed ahead. After this, the hardness profile of the bended zone was outlined, verifying possible hardness variations along the sample profile resulting of the bending mechanical work.

Corrosion tests were carried out following the ASTM A-262 standards. Considering the practices recommended by this standard, practice A was adopted as first step in order to evaluate the corrosion resistance. If the corrosion detected exceeds the stipulated by the standard, new steps will be necessary following other practices as described in the referred standard. Practice was performed immerging each sample on a solution of 100g of Oxalic Acid diluted on 900ml of distilled water and stirring until all crystals are dissolved. An electrode of AISI 316 stainless steel was used to carry out the test. A power supply providing 15V and 5A (current needed for the exposed sample area) was connected during 90 seconds between the polished sample and another electrode, both immersed within the solution. After this, the sample was washed in water and dried with compressed air, being afterwards analyzed by optical microscopy.

Plastic recovering tests were also made in order to evaluate the technological properties of these stainless steels. Three different angles were selected in order to analyze the angle deviation after the press break unloads the samples. An accurate goniometer was used in order to measure the angle that remains in the sample after the mechanical work. These tests were performed considering that one of the main applications of the ferritic stainless steel can be the metallic furniture, which is usually subject to press break operations.

Other technological tests were performed in order to analyze the appetence of these materials to deep drawing. For this evaluation, deep stock pots with 28cm diameter and 35cm height were produced in four different steps: the process begins by cutting a blank from a 0.8mm thickness sheet metal, followed by a medium deep drawn operation. The third step is to produce the final height of the pot performing a reverse deep draw operation. Finally, the button of the pot (cylindrical shape) was subjected to an expansion by an elastic polymeric punch with the aim of obtaining a pot-bellied. After these operations, surfaces were carefully analyzed in order to identify possible defects and rupture. Surface aspect was also inspected because this is a special requirement in this kind of industry.

RESULTS

Tensile tests allowed us to obtain several mechanical data about these materials. The summary of the results can be seen in table 2.

Table 2 - Summary of results after tensile tests

	AISI 201	AISI 304L	AISI 441
Yield Strength [MPa]	382.4	357.4	379.7
Ultimate Strength [MPa]	723.8	643.7	476.3
Maximum Force [N]	28951	25750	22870
Elongation [%]	73.4	68.7	42.5
Young’s Modulus [GPa]	207	218	216
Poisson’s Ratio	0.35	0.39	0.39
Necking [%]	47.0	42.7	40.6

As shown in the table 2, AISI 441 ferritic grade presents similar Yield Strength and Young’s Modulus. However, its Ultimate Strength is a little bit lower. Moreover, its Elongation is significantly lower than the austenitic grades, effect that has not parallel in the Necking effect. A reduced elongation can limit some mechanical operations such as severe plastic deformation processes.

The fracture surface after tensile tests was also analyzed, showing that all the materials tested displayed ductile behavior at room temperature but, AISI 304L and AISI 441 present a clear plastic deformation on the surface fracture, whilst AISI 201 shows a sharp edge with moderated plastic deformation. The fracture surfaces for all the materials tested are depicted in figure 1.

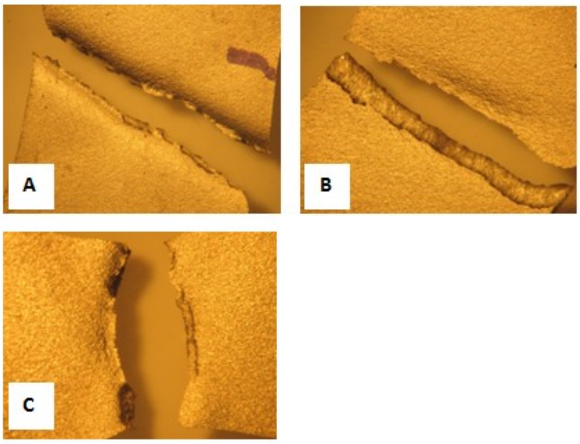

Fig. 1 – Fracture surface of the (a) AISI 304L, (b) AISI 201 and (c) AISI 441

Tests carried out under load-unload conditions show that these materials do not present work hardening effect. Effectively, the force needed to perform the deformation stipulated for these tests in the next cycles is a little bit lower than the necessary to make the first cycle.

This behavior was common for all the materials tested. In fact, if these materials are susceptible to work hardening, the force needed to produce the same deformation should be higher. Thus, it can be sentenced that these materials are not susceptible to work hardening with this level of mechanical work. Figure 2 shows a Force-displacement curve resulting of one of the tests carried out over AISI 304L stainless steel, denoting the related above. This behavior is quite similar with the remaining materials tested.

Although the hardness tests show that the values obtained for the nucleus is higher than the surface hardness for the austenitic grades, the ferritic grade (AISI 441) shows higher hardness on the surface than in the nucleus. This phenomenon can be related with the rolling steps and heat treatments that each material has been submitted

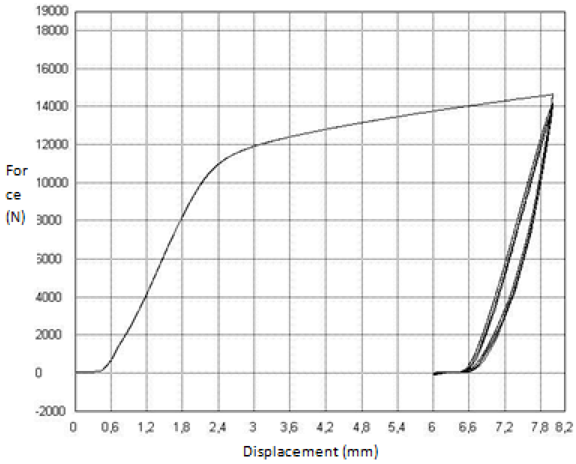

Fig. 2 – Load – Unload curves resulting of the tests performed over the AISI 304L stainless steel

Table 3 – Summary of hardness results

	AISI 304L	AISI 201	AISI 441
Internal hardness (HV_{30})	203.1	223.1	164.3
Surface hardness (HV_{30})	172	216.7	182.1

After these tests, bending actions were made over other samples with the purpose of evaluating the work hardening effect, which can be observed in figure 3. The rounded samples did not present hardness changes for all the tested materials. On the other hand the samples subjected to acute angle shows an increased hardness (about $100HV_{30}$ higher) on the angle which is not verified on the non-deformed area. This effect is lesser for the AISI 441 ferritic grade than the austenitic grades, denoting lower work hardening effect.

Fig. 3 – Bended samples used to evaluate the work hardening effect

Corrosion tests allow to observe that all these materials present a good corrosion resistance. Effectively, after tests, the samples denote only smooth corrosion marks as depicted on Figure 4. While AISI 304 and AISI 201 austenitic grades presented some small ditches in the grain boundaries and small steps in the grains, AISI 441 ferritic grade presents well-defined ditches but none is able to surround completely the grains. Some steps are also present on the grains face.

Furthermore, in these conditions, these materials can be considered able to resist to corrosion. Despite of the protection conferred by the Ti and Nb additions, the AISI 441 ferritic grade denotes a little bit worst resistance to corrosion than the other grades. Attending to these results, no other practices were applied to test the corrosion resistance as recommended in the standard documents.

Fig. 4 – Surface aspect of (a) AISI 304L, (b) AISI 201 and (c) AISI 441 after corrosion tests

Bending tests performed on a press break system allow to observe that AISI 201 austenitic grade shows the higher elastic recovery ratio under all the test conditions, accompanied close by the ferritic AISI 441 stainless steel. As can be seen in table 4, AISI 304L austenitic grade presents the best accuracy in terms of angle required versus angle achieved. However, this issue cannot be a restriction for the common use of the AISI 441 because the press break process can be controlled in order to compensate and overcome this problem.

Table 4 – Data about “angle required versus angle achieved” after press break operations

	AISI 304L	AISI 201	AISI 441
88º	87º45’	93º36’	92º45’
90º	91º21’	96º10’	94º15’
135º	134º30’	136º15’	134º15’

Deep drawing tests allow to understand how important can be the elongation difference detected on the tensile tests. After the second step (first deep drawing operation), all the samples produced presented very good accuracy, not denoting any signs of rupture. The third step (reverse deep drawing) was also carried out without problems. The same did not occur when the fourth step was done (pot-bellied effect). While austenitic grades presented a very good performance on this operation, the ferritic AISI 441 broke, showing a significant crack surrounded by well-defined grooves of crossed plans (Luders bands). This failure proofs that this kind of material presents deformation restrictions and the plastic deformation expanding requirements does not can exceed its moderated performance. Thus, this restriction can avoid the use of this material where large elongation is required. Figure 5 shows the ferritic AISI 441 failure after pot-bellied operation.

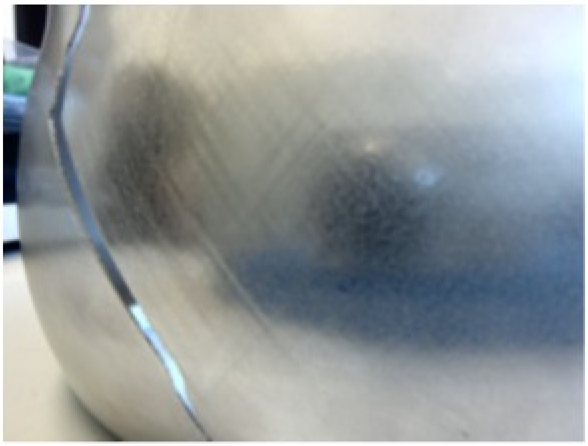

Fig. 5 – Failure occurred after pot-bellied operation on mechanical press with an elastic polymeric punch

Furthermore, the superficial look requires 25% more time in polishing operations than the austenitic grades in order to obtain similar brightness on the pots surface.

Thus, ferritic AISI 441 stainless steel shows to be an alternative to austenitic grades, due to the fact that it presents similar mechanical and corrosion resistance. This issue allows the use of this material in several applications where the material cost is a critical factor for the companies due to the unavailability of costumers to pay the exceed price resulting of the Nickel increased cost. Then, industrial managers can look at the ferritic AISI 441 as a material able to use in their products allowing a more competitive position in the market. However, some applications can be out of this group mainly because of two main reasons: the polishing operations are longer for AISI 441, increasing the product labor cost and also because this material is not able to perform high expansions by plastic deformation due to its limited elongation. Nevertheless, only a few fields of applications can be restricted in this area.

4. CONCLUDING REMARKS

After concluded this work, the following remarks can be drawn:

- Austenitic AISI 201 stainless steel presents the higher mechanical resistance and hardness in the group of materials tested;
- Ferritic AISI 441 stainless steel presents some limitations on Elongation and Necking properties. Despite of this, the fracture surface of this material presents a clear ductile behavior;
- Work hardening was only felt when severe mechanical work was done over the material. This behavior was common for all the materials despite the fact that AISI 441 is less sensitive to this effect;
- All materials presented enough corrosion resistance, attending the standards procedures and the results obtained;
- Ferritic AISI 441 and Austenitic AISI 201 show higher elastic recovery phenomena when compared with the common AISI 304L;
- The limited elongation presented by AISI 441 restricts its application for applications where severe expansion plastic deformation is required.

As main remark, it can sentence that ferritic AISI 441 can be applied in many applications where the superficial aspect is not very important or, being important, the increased cost in polishing operations be competitive attending to the advantages presented by material cost. Otherwise, we can keep in mind that this material presents some plastic deformation restrictions, mainly when submitted to severe expansion on deep drawing process. However, the lower cost of the ferritic AISI 441 can keep several products competitive in the market, offering similar properties to austenitic grades.

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PROJECTS PRESENTATION

PROJECT

UBIQUITOUS ORIENTED EMBEDDED SYSTEMS FOR GLOBALLY DISTRIBUTED FACTORIES OF MANUFACTURING ENTERPRISES

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Abstract: The main objective of this project is to deliver next generation of methods and means for development and production of hi-tech products in modern manufacturing enterprises. Synergetic result comes from domains of a) management and control architecture, b) distributed systems of ICT, c) ubiquitous oriented embedded systems.

Keywords: Ubiquitous manufacturing systems, High-tech products, Globally distributed, Embedded systems, ICT.

1. PROJECT SCHEME PROGRAM

The project "UBIQUITOUS ORIENTED EMBEDDED SYSTEMS FOR GLOBALLY DISTRIBUTED FACTORIES OF MANUFACTURING ENTERPRISES" is a project approved in the EUREKA Project (E! 4177 PRO-FACTORY UES) and financed by Portuguese Foundation for Science and Technology FCT under the FCT COMPETE – QREN Program, with project reference PTDC/EME-GIN/102143/2008.

2. PROJECT SUMMARY

Most production processes are still based on Taylorian paradigm that builds on deterministic operations in production, on static environment and on equilibrium between market demands and capabilities of production process. Real nature of modern manufacturing is quite the opposite: it is about dynamics, stochastics, complexity and globalization. A new approach is needed.

This project is about development of new concepts for distributive adaptive manufacturing that include simultaneous development in domains of manufacturing, informatics and embedded electronics. The goal is to restructure modern production from hierarchical into flat, adaptive, distributed, self-organized production systems.

We propose:

a) To develop a manufacturing concept that will give structures for further optimization of globally distributed manufacturing systems and of a production environment as a whole while embracing new ICTs and new technologies of embedded systems to build such structures.

b) To design and build a family of ubiquitous oriented embedded systems that will give means to implement new non-hierarchical manufacturing structures. Development of these ubiquitous oriented embedded systems will result in a family of new physical devices for monitoring and control of manufacturing systems.

Entities of the proposed project are:

a) Development of a new manufacturing concept for flat, adaptive, distributed, self-organized production systems.

b) Development of embedded systems, based on wireless connectivity, in a form of small devices that are seamlessly integrated with production machines, operators, parts in production, materials and transport systems to gather data and to control some machines' functionality.

c) Development of a distributed communication system in a form of component-built entities, that run on workstations and interface small wireless devices that interact with the physicalities of a manufacturing process.

d) Development of a scalable web-based application for monitoring, control, micro-planning and prediction of stochastic events (failures) and (quality) fluctuations in a geographically distributed manufacturing enterprise.

The interdisciplinary nature of the project involves professionals from fields of manufacturing, informatics and electronics engineering. The project brings contributions in each of these fields. The most important is synergetic contribution, which is a next level in concept, construction and execution of a manufacturing system. The system of first implementation produces high-tech products, i.e., turbines and sub-components for hydroelectric power plants.

Clarification:

Development and production of high-tech products, as sub-components of electric plants, is a complex process. The common practice is to support data management with some Enterprise Resource Planning (ERP) system. These systems do not support manufacturing process in a broader sense, which includes product development, production and assemblies in factories and on the spot.

3. PLAN AND METHODS

Motivation for this project is multi-dimensional:

a) Need for thorough control in production of custom high tech components and subsystems (in the case study, for hydroelectric power plants).

b) ICT support systems for the purpose of a) do not exist. Present Supervisory Control and Data Acquisition (SCADA) systems mostly register events in a sense of machine functionality and they transfer NC code. Systems for local and remote production monitoring do exist already. As of current scenario, there is no de-facto standard for interfacing different Programmable Logic Controllers (PLCs). Some communication in production is performed via RS232 serial interfaces, some over current loops, some over 488 interfaces, some over Field bus, some over different SCADA systems. Besides of hardware nuances, many different communication protocols are being used for information exchange.

c) Finding the manufacturing practices of a) and similar productions can be restructured, i.e., optimized for quality, cost, and production times. Our past work on definition of an Elementary Work System (EWS) and different production structures, based on EWS, and pilot implementations of these, support the claim c).

d) ICT and embedded systems technology offer amazing new possibilities for informational integration of machines, products, operators, processes, managers, accountants, and not last, customers. These possibilities have that much potential that conceptually new manufacturing systems are now feasible.

In the current global scenario of recession and at the same time very high expenses of hiring skilled human labours, it is very important to have a different technological and organisational strategy which assures more efficiency and quality of production with the resources at hand.

Ubiquitous is also the subject of research in the last years. This is mainly research within the area of ICT towards ubiquitous computing systems. Very recently, the concept of Ubiquitous Manufacturing (UM) has appeared, based on use of the ubiquitous computing systems as a new generation of the computer operating system but keeping the signature of the company organization and business plans. Therefore, ubiquity within the concept of UM is, by nature, an optimisation tool.

The technological development envisaged through the proposed project is a development of non-hierarchical, i.e., conceptually new and flat, adaptive, distributed, responsive and self-organized structure for globally distributed manufacturing with the help of:

a) Generalization in data monitoring and control. Development of a dedicated hardware platform, optimized for cost and performance in production monitoring and control. Development of self-contained applications for production monitoring and control which run on the dedicated hardware platform. This approach gives functionality of network of PCs at a fraction of the cost. (Dedicated embedded systems are for integration into new machines, and to retrofit in existing machines.)

b) Development of an ICT system, that complements both, the new self-organized manufacturing structure and ubiquitous gadgets, which report and control aspects of material production. The new structure supports real time decision making with real time data, which are in most appropriate form and extent. The expected results at the end of the project will be new products on a high level and on a low level.

New products on the high level are:

a) A new manufacturing model for build-up of most self-organized production systems, based on real time decision making that is supported by relevant information in real time.

b) An embedded system platform, optimized for needs of monitoring, control, message exchange, reporting and logging in material production.

c) An ICT system that connects the manufacturing paradigm and the gadgets (embedded system platform) into a self-organized globally distributed system of a manufacturing enterprise.

And, the new products on the low level are:

Software applications, running on gadgets (unified embedded system platform) in discrete production, for near-zero production down time, with help of distributed micro-planning and anticipation of failures.

A prototype is a distributed, adaptive, self-organized manufacturing system for world-wide production of heavy machinery high tech custom components. i.e., for production of sub-systems for buildup of hydroelectric power plants.

Cooperation in this Project is defined by delivering work tasks to organizations (of this consortium) that are most capable of performing a particular task. Consortium consists of specialists from areas of “production engineering”, “designing of distributed ICT systems”, “embedded systems development” and also from “production of hi-tech products in worldwide-distributed production systems”. Since the fields of expertise do complement, and not rival each other, there are well-defined interfaces among activities of Partners. The added value of the Project stems from synergy of developments in different fields (production engineering, informatics and electronics). Brief description of role played by each partner:

1) University of Ljubljana contributes on the conceptual level by an architecture of most self-organized work structures for flexible geographically distributed production of custom high tech products, and design and development of distributed monitoring, prediction and control system.

2) Litostroj EI is involved into development of interactive user interfaces for collection; control and real time messaging of shop floor events and activities; evaluation and refinements of real time decision making; performance analysis of machine and workshop utilization.

3) P.P.C. Buzet d.o.o. will develop interactive user interfaces for die casting data collection.

4) Fundacion Prodintec will implement Advanced Management Production methodologies, Plant reengineering projects and Process simulation services.

5) Grupo Intermark 96 S.L will be responsible the physical systems integration concerning plant data capture in real-time.

6) Universidade do Minho will develop an organizational model for the UES based workshop which will comprise organizational infrastructures for providing higher level supporting services for the UES object manufacturing and business processes. The main purpose of this infrastructure is to provide higher degree of the UES robustness in terms of interoperability, reconfigurability and agility, efficiency and effectiveness. The special focuses will be on services and tools for UES organizational network development, and on human role and relationship in an UES, as the most important part of an organization, spanning roles from the equipment operators to the highest level management. Also, Universidade do Minho will contribute to Testing of the organizational model of the UES based workshop, and Promotion and dissemination of the project results in Portuguese industry.

7) Advanced Computer Service will be developing a ubiquitous based embedded hardware using RFID, USN (Ubiquitous Sensor Network), mobile and wireless LAN technology that interfaces various production equipment in real time.

8) G-SCOP Laboratory from Universite Joseph Fourier, will develop new multi-agent approach to control and scheduling of manufacturing process in Flexible Manufacturing Systems (FMS). The case of SME-SMI.

4. POTENTIAL INDUSTRIAL MARKETS OF THE PROJECT RESULTS

There are two different markets to be addressed at this question. One is the market of high tech custom components and sub-assemblies for heavy machinery, e.g. turbines for electric plants. As a producer achieves shorter turnaround times (from design to operation on the construction spot) with less random events in between, he gets advantage over other producers. Additionally, optimized production process gives more space for negotiation of the market price since the actual cost of production is lower. When all producers in the branch conquer new production technology (eventually, they are forced to do so), costs and associated market prices decrease. In general, this is good for national economies.

The second market is the one for the new manufacturing system itself. As it shows a success, most producers of custom high tech products will need it. We anticipate spread of new manufacturing system into other areas, customized automotive production being most tempting.

Both sizes, of the first and of the second market, are worldwide.

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LEAN LEARNING ACADEMY: AN INNOVATIVE LEARNING CONCEPT IN ENGINEERING CURRICULA

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Abstract: Today, companies are faced with decreasing profit margins due to economic crisis and global competition. At the same time, in many higher educational institutions, students attend rather unattractive courses by sitting and listening to lecturers teaching ex-cathedra. This paper describes how Lean Learning Academy, an innovative training programme on lean manufacturing, can contribute to the competitiveness of companies, to the employability of employees and students, to the motivation of students, and to the attractiveness of engineering curricula. The training programme can be considered as a successful innovative alternative for the traditional way of teaching.

Keywords: Lean, game, training, course, company, higher education, engineering

1. INTRODUCTION

An important way for companies to stay competitive is to focus on production efficiency and cost reduction (see e.g. Tinham, 2005.). That is what lean manufacturing is aiming at (see e.g. Wood, 2004). The maximum benefit from lean manufacturing is gained by considering all its elements (i.e. principles, tools, and mindset) together as a system, and by practicing them every day in a consistent manner. As such, companies should be able to train their managers and employees continuously in lean manufacturing principles, tools, and mindset.

At the same time, higher educational institutions are trying to prepare their students to function successfully in professional life. They are looking for ways to better develop their students' competences. More specifically, lecturers are looking for learning methods that raise students' interests, motivate them, make them better understand complex matters and allow them to study anytime and anywhere using course materials published on the web (see e.g. Yazici, 2006; Dobson and Shumsky, 2007).

To satisfy the need for training lean manufacturing principles in companies on the one hand and to improve engineering students' employability in professional life on the other hand, an innovative training programme on lean manufacturing in the framework of an Erasmus–Lifelong Learning Programme (LLP) project is being developed.

The paper is organized as follows. In section 2, we elaborate on the different features of this project. In section 3 we touch upon the innovative didactical concept of the training programme. Section 4 concludes the paper by presenting some critical success factors for academics considering using simulation games in higher education.

2. PROJECT FEATURES

The training programme is developed in the framework of an Erasmus-LLP project (that started in October 2009 and ends in September 2011). For this project, cooperation is set up between lean experts of a university and a company highly experienced in lean manufacturing in five different countries (Belgium, Poland, Sweden, Romania and Portugal). The goal of this cooperation is to develop a state-of-the-art training programme consisting of a lean production simulation game that is alternated with 16 on-line course modules on different lean topics. Apart from teaching lean principles and tools, the training programme also aims at developing a lean mindset. This means there is a lot of attention to and feedback on the lean behaviour of the participants. In order to enhance the output quality, the authenticity of incorporated cases and the relevance of all material included, a lot of external experts (apart from the company experts) are involved in the project. Since a lot of development has to be performed in only two years' time, monitoring the project progress is important from the very beginning. As such, measures should be taken to keep all partners on track. In the following subsections, we will zoom in on these different project features.

2.1. PROJECT PARTNERS

To develop such an innovative training programme, a collaboration is established between lean experts from five EU-universities, each supported by a company with a lot of expertise in lean management as represented in Fig. 1. This partnership assures a didactically well thought training programme with relevant and authentic content. Indeed, the company partners contribute to the project by providing the academic partners with their expertise (a priori and a posteriori) and e.g. with authentic cases; the academic partners use this expertise to develop the training programme. EURASHE (European Association of Institutions in Higher Education) is added as additional partner to help disseminate the project results to her wide member network.

Fig. 1 - Logos of universities and companies involved in the project

2.2. PROJECT DELIVERABLES

Together, the five academic partners develop a state-of-the-art training programme in lean manufacturing consisting of 16 on-line course modules about different lean topics and a lean production simulation game. At their university, all academic partners reserved a production simulation room to set up the lean production game. In another room nearby, a team corner is equipped with team instruments and performance measurement tools.

A website (Lean Learning Academy, 2009) is developed where the different **on-line course modules** are easy to retrieve and ready to use as lecturer. Each module is supported by PowerPoint presentations. Explanations in the text box below most slides allow participants to use these course modules as e-learning packages. The modular approach also allows to compose different variants of learning sessions, from one-topic lessons to a complete lean programme of one week or even more. The industrial partners safeguard the professionalism and the technological relevance of the course contents while the academic partners safeguard their didactical quality and pedagogical relevance.

The lean learning contents consist of elements in the following three principal areas: operating system, mindsets and behaviours and managerial issues:

- The **operating system** is the 'tool kit', or a collection of tools and techniques that is used to run a manufacturing system under optimal conditions. Safety assurance, problem solving, quality assurance, visual management, variability reduction, process improvements, process measurements, total productive maintenance and standardized work are only a few examples.

- The **mindsets and behaviours** component focuses on lean behaviour. Aside the lean leadership behaviour, which is definitely a task for management, each employee needs to understand and get acquainted with the lean manufacturing mindset. By doing so, every employee is directly involved in the continuous improvement efforts of the direct work environment and the business process. Lean behaviour is trained during the theoretical lessons by introducing a number of mutual agreements between coach and participants to keep the classroom clean and tidy and by paying attention to a few other lean rules. Here follow some examples to clarify this:

    - When entering and leaving the classroom, every participant has to put a strip with his name in the right column (in/out) on a magnetic board outside the classroom.
    - Every participant must be on time for the sessions.

- When leaving his place, a participant must put his chair right under the table and leave materials on a clearly marked dedicated position on the table.
- The dress code for the classroom is as follows: safety jacket, safety shoes, no helmet, no safety glasses, no earplugs, no gloves.
- …

Each time a participant violates a rule, the coach will give him a yellow note (a yellow post-it) with the violated rule written on it. These yellow notes are input for the team reflection meetings in order to come up with improvement actions. They stimulate a lean attitude of continuous attention and discipline.

- The managerial issues are more focused towards leaders with a broader responsibility in the manufacturing facility such as superintendents, production leaders, quality, and logistic managers. Lean leadership behaviour is a core element in that they have to show exemplary behaviour towards the other employees. Specific management tools like policy deployment, confirmation process, time and date management, coaching and assessment are also part of it.

The **lean production simulation game** enables the application of the lean concepts into a small scaled production line. In that production environment, a gift box with two ball pens is assembled. A lot of lean concepts are applicable like e.g. 5S, standardised work, line balancing, setup time reduction, one piece flow, layout optimisation, JIT/kanban, push and pull production, customer order decoupling point and many others. During a round, a PC programme graphically visualises customer lead time and a beamer projects it on a wall to allow participants to follow up customer orders. Lean behaviour is trained during the lean production game by keeping participants' attention on a number of safety rules. Again, some examples to clarify this:

- At the entrance door of the simulation room, signs indicate who is allowed to enter the room and what kinds of protection clothes people should wear inside the room.
- Inside a marked area around certain workstations, it is mandatory to wear additional safety clothes like e.g. gloves.
- The implementation of pull production requires from the workers the discipline not to produce when there is no demand from the next workstation, although they have available all necessary production resources.
- …

And again, every violation against these rules leads to a yellow note.

By running several production rounds, the process improvements are leading towards a best-in-class lean production process. After each round productivity and efficiency metrics are visualised on the team board and discussed in the team.

During the entire course the participants are part of a team of seven to nine persons. Each team has its own fully equipped team corner with visualisations, performance measurements, team management tools, follow-up instruments and communications. The team dynamics and team member interaction is an important part of the lean learning process.

2.3. PROJECT MONITORING

In order to end up with a training programme that meets the high standards for training employees of well-known companies, project progress and output quality are continuously monitored. This monitoring is performed by several experienced people:

- **Resonance groups:** All five academic partners compose their own resonance group consisting of at least ten people from higher educational institutions and companies. To enhance the relevance and the quality of the project output, at least three times in the project lifetime, this resonance group gives feedback on materials developed by their academic project partner.
- **External evaluator:** An independent external evaluator (from Amelior management consultants, Belgium) monitors project output quality and project progress. He gives feedback on the published project deliverables, contacts partners who are far behind schedule and coaches them to keep pace with the project milestones. His reports are published on the project website.
- **To-do list published on the website:** In the 'Partners Only' section of the project website, a to-do list is added in which is mentioned for every milestone what should have been done by each partner. As soon as the task is done, the web master changes the red X in a green OK button. When there appears an arrow on the green button, clicking on it activates a link to an output document related to the task. This is represented in Fig. 2.

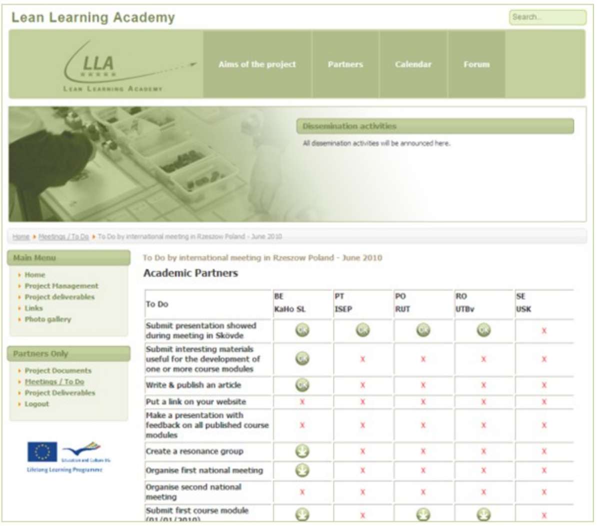

Fig. 2 - To-do list in the 'Partners Only' section of the project website

Apart from the above mentioned experienced people, eight national and four international project meetings are scheduled to discuss project progress and output quality among partners.

3. INNOVATIVE DIDACTICAL CONCEPT

The training programme can be seen as an innovative didactical concept. Rounds of the lean production game are alternated with short courses on lean topics. The learning cycle starts with the bottom rectangle as represented in Fig. 3:

1. The lean learning programme starts with a first round of the lean production game.
2. After that round, team members compute and measure lean key performance indicators (KPI's).
3. Looking at the indicators, team members formulate problems and/or make suggestions for improvements.
4. To assist the team in fully understanding the problem and providing the team with an appropriate improvement tool, the coach teaches the related course module.
5. Afterwards, the team members use this knowledge to find the most appropriate improvement actions.
6. As soon as the whole team agrees on the actions to be taken, they implement them in the lean production game by changing the game setup. Then, the team is ready to play a next round and a next learning cycle can start.

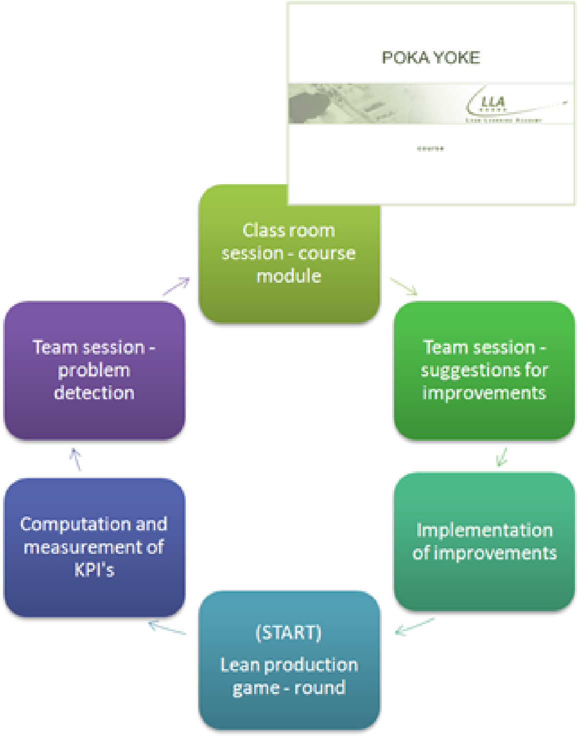

Fig 3 - The innovative learning cycle

4. CONCLUSIONS

In this paper, we elaborate on an innovative training programme on lean manufacturing in the framework of an Erasmus–LLP project. This programme is developed to satisfy the need for training lean manufacturing principles in companies on the one hand and to improve engineering students' employability in professional life on the other hand.

Positive experiences with a former lean production game in an educational setting let us expect that this innovative training programme will challenge his participants (Martens, 2006). All academic project partners agreed to implement it into their engineering curriculum. We know this makes a curriculum more attractive, motivates students, enhances learning yields and results in higher employability. Moreover, this project establishes a knowledge network between lean experts and therefore lays the foundation for successful cooperation in future projects.

However, academics who are considering using simulation games in higher education should consider some critical success factors.

- A good simulation game confronts students with the results of their proposed actions. It gives them an impression of the huge impact of certain improvement actions on KPI's. Often, many years after participating, some parts of the game are indelibly printed in on their memory.

- The game development team must be convinced that the simulation game creates a unique learning experience for his students. Students will not stay motivated if the simulation output is in line with their expectations. In that case, a simulation game is not the most efficient didactical learning method.
- For the current generation of young people, there should be enough learning experiences in the simulation game which should intermittently follow each other. The game should advance with swiftness to prevent that students get bored.
- Ask students about their learning experience afterwards and correct or improve game aspects accordingly. Prepare for new directions in the storyboard of the game depending on decisions students possibly can take.
- And last but not least: do not undertake the whole process on your own. Involve some colleagues. Not only developing, but also preparing and coaching a simulation game is very demanding. We think here of the whole setup that must be checked before you start the game, the required interventions on several locations at the same time during the game, the quick setup change between two successive runs of the game, etc.

ACKNOWLEDGEMENTS

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that started on October 1, 2009 and ends on September 30, 2011. This project is granted by the EU and co-financed by the academic partners.

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PROJECT

DESIGN AND EVALUATION OF USER INTERFACES FOR REMOTE COLLABORATIVE CONTROL OF MANUFACTURING SYSTEMS

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Abstract: The main scientific objectives of this project are: 1) to develop different end-user interfaces for remote collaborative control of manufacturing systems, in order to support effectiveness and efficiency of the control process in environments of globally distributed factories and 2) to evaluate the designed interfaces in terms of interfaces performance measures, such as friendliness, efficiency, robustness, acceptance, etc.

Keywords: Manufacturing systems, Interfaces, Collaborative work

1. PROJECT SCHEME PROGRAM

The project "DESIGN AND EVALUATION OF USER INTERFACES FOR REMOTE COLLABORATIVE CONTROL OF MANUFACTURING SYSTEMS" is a project developed under the program of scientific and technological cooperation between the Republic of Portugal and the Republic of Serbia for the period of 2011-2012.

2. PROJECT SUMMARY

Available previous research shows that ergonomics and some human related disciplines have to be added to traditional engineering disciplines to cope with such growing complexity of manufacturing systems. Therefore, the main project objectives are:

1) to develop different end-user interfaces for remote collaborative control of manufacturing systems, in order to support effectiveness and efficiency of the control process in environments of globally distributed factories and

2) to evaluate the designed interfaces in terms of interfaces performance measures considering interaction requirements such as usability, navigation and readability, that include aspects such as friendliness, efficiency, robustness, acceptance, etc.

The main project objectives will be realized through the following phases:

a) Analysis of related works about available interfaces between the Clients, Brokers and Ubiquitous Manufacturing Systems (UMS) from the aspect of screen types and sizes, video-cameras and VC systems

b) Defining the methodology for experimental testing of all types of interfaces (sample size, method, study design)

c) Defining the procedure of experimental testing (task + questionnaire)

d) Statistical data analysis (usage of ANOVA, factor analysis etc. for explaining the differences and generalizing the results)

e) Results discussion and conclusions development – evaluation of interfaces from the aspect of performance measures

f) Ideas for future work in the field.

The most important results of this project include exact quantitative evaluation of interfaces in manufacturing control from the aspects of interaction requirements (usability, navigation and readability, as well as the aspects of friendliness, efficiency, robustness, acceptance friendliness, efficiency, robustness, acceptance, etc.), and recommendations for their usage. Quality, innovative approach and original scientific objectives of this project:

a) Offer a solution to the priority problems of user interfaces in the field of collaborative remote control of manufacturing systems,

b) Encourage further networking and regional integration and new bilateral and international projects, in order to implement an experiment on a larger sample of participants

c) Require the inclusion of a greater number of younger scholars.

Actuality of this project is reflected in the design and evaluation of user interfaces for collaborative remote control, as under-researched area. A similar, multi-disciplinary research is rarely carried out and is rarely available. That is the reason why expected results include new projects application (FP7), papers publication on conferences and in journals with IF, book chapters, seminars for academic community and industry etc.

3. METHODOLOGY AND WORK PLAN METHODOLOGY

All members of this project will contribute to realizing the targets of the project. The successful collaboration between the Coordinators and their teams is necessary in all stages of the two annual project. The Coordinators are responsible for the control of the project and the working relationships which will be developed. The project is a continuous learning process for all participants, and participation at conferences, and results in MSc thesis and PhD dissertation will play a fundamental role towards this direction. Proposed phases of project are going to be realized through the following tasks that will be controlled by coordinators:

1. Start-up & preparation,

2. Analysis of related works about available interfaces between the Clients, Brokers and UMS from the aspect of screen types and sizes, video-cameras and VC systems,

3. Planning and design of different end-user interfaces for remote collaborative control of manufacturing systems,

4. Methodology for experimental testing of all types of interfaces (sample size, method, study design),

5. Procedure of experimental testing (task + questionnaire)

6. Statistical data analysis (usage of ANOVA, factor analysis etc. for explaining the differences and generalizing the results),

7. Results discussion and conclusions development – evaluation of interfaces from the aspect of performance measures,

8. Dissemination of the results and project closure.

WORK PLAN

Year 1

WP1: State-of-the-Art and end-users requirements – Analysis of related works about available interfaces between the Clients, Brokers and UMS from the aspect of screen types and sizes, video-cameras and VC systems. Analysis of the manufacturing companies requirements concerning the user-interfaces for the globally distributed factories architecture.

WP2: Design and development of user-interfaces for the globally distributed factories architecture.

Year 2

WP3: Validation of the developed user-interfaces for the globally distributed factories architecture – 1) Defining the methodology for experimental testing of all types of interfaces (sample size, method, study design); 2) Defining the procedure of experimental testing (task + questionnaire); 3) Statistical data analysis (usage of ANOVA, factor analysis etc. for explaining the differences and generalizing the results); 4) Results discussion and conclusions development – evaluation of interfaces from the aspect of performance measures

WP4: Exploitation plan development and dissemination of the results in the academic community and industry in Serbia and Portugal. Future work definition.

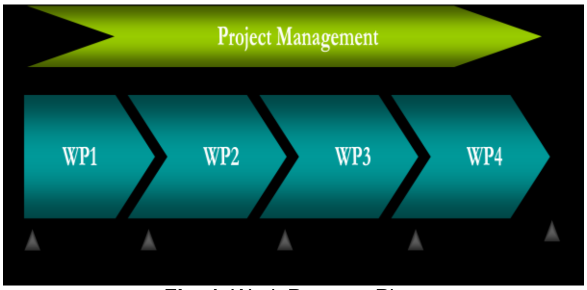

Fig. 1. Work Program Plan.

4. POTENTIAL INDUSTRIAL APPLICATION OF THE PROJECT RESULTS

Based on the results of the user-interfaces development and evaluation, it will be developed a guide for successful application of each of them in manufacturing systems of the companies in Serbia and Portugal. The interfaces to be developed are applicable in 1) any manufacturing company that uses CNC manufacturing technology, and 2) for micro companies that provides services of manufacturing systems control to the companies manufacturers. The applicability domain in the micro-companies providers of services, are of the special interest as it implies a potential for opening new working places with low level investment and, additionally, promoting higher level of service products, internationalization through networking on the international market of advanced manufacturing services, and, at the end, the contribution to the knowledge based economy.

Industrial application in Serbian and Portuguese industrial enterprises will be promoted through the training seminars, two in each partner country.

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AUTHOR INDEX

SUBJECT INDEX*

*by papers' keywords

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Presently, he is the member of the following professional societies and scientific networks:

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- Member of the IFIP WG 5.5 – "COoperation infrastructure for Virtual Enterprises and electronic business – COVE"
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