SCHOOL OF MANAGEMENT AND TECHNOLOGY
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M **MASTER**
INTERNATIONAL MANAGEMENT

The Impact of Digital Transformation on Environmental Sustainability and Internationalisation Strategy

Joana Catarina Rocha Magalhães da Silva

11/**2023**

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Joana Catarina Rocha Magalhães da Silva
Professor Jorge Oliveira and Professor Ana Borges

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To my family and friends, thank you for always believing in me, your words of comfort, and being my home. Without you, the journey would have been more difficult.

Finally, I want to thank the School of Management and Technology for welcoming me for the six years of my academic career. I'll take with me lifelong memories of the years I spent here.

My sincere thanks to everyone.

Abstract

This research presents a Bibliometric review of scientific articles on Digital Transformation (DT), Environmental Sustainability, and Internationalisation strategy and a Structural Equation Model (SEM) employed with a diagonally weighted least squares (DWLS) estimator. The study's objective is to analyze the impact of DT on Environmental Sustainability and Internationalisation strategy.

Our methodology for the bibliometric analysis involved examining the annual growth of publications, country production, prominent sources, affiliations, and globally cited countries. Furthermore, we conducted a thematic analysis using word cloud and thematic maps to explore the evolution of research themes.

The findings reveal notable trends and patterns within the literature, including significant growth patterns, key countries and affiliations, and globally cited countries. The thematic analysis identified major themes and topics that have emerged in this field.

As for the SEM, the methodology involved an online survey that resulted in 296 eligible responses from Portuguese firms located in the north of Portugal with primary codes from 10 to 32 and an open email, followed by a Factor Analysis to assess the construct validity, adequacy, consistency, and reliability of the multi-item questionnaire. The hypotheses were assessed through the SEM with a DWLS estimator.

Findings reveal that participants comprehend that DT, environmental sustainability, and internationalization have favourable impacts on firms, corroborating the information discussed in the literature.

Additionally, with the SEM analysis, results revealed that DT has positive and significant direct effects on enterprise performance, environmental sustainability, and internationalization. However, that impact is bigger on enterprise performance, followed by internationalization strategy and environmental sustainability.

Keywords: Digital Transformation, Environmental Sustainability, Internationalisation, Bibliometric analysis, Structural Equation Model.

Resumo

A presente dissertação apresenta uma revisão bibliométrica de artigos científicos sobre a Transformação Digital (TD), a Sustentabilidade Ambiental e a estratégia de Internacionalização e um Modelo de Equações Estruturais (MEE) utilizando um estimador de mínimos quadrados ponderados diagonalmente (EMQPD). O objetivo do estudo é analisar o impacto da TD na Sustentabilidade Ambiental e na estratégia de Internacionalização.

A metodologia para a análise bibliométrica consistiu em analisar o crescimento anual das publicações, a produção dos países, as fontes proeminentes, as afiliações e os países mais citados globalmente. Além disso, foi efetuada uma análise temática utilizando a nuvem de palavras e um mapa temático de forma a explorar a evolução dos temas de investigação.

Os resultados revelam tendências e padrões notáveis na literatura, incluindo padrões de crescimento significativos, países e filiações importantes e países citados a nível mundial. A análise temática permitiu identificar os principais temas e tópicos que emergiram neste domínio.

Quanto ao MEE, a metodologia consistiu num inquérito *online* que resultou em 296 respostas elegíveis de empresas portuguesas localizadas no norte de Portugal com o Código de Atividade Económica de 10 a 32 e um e-mail associado, seguido de uma Análise Fatorial de forma a avaliar a validade, adequação, consistência e fiabilidade do questionário composto por vários itens. As hipóteses foram avaliadas através do MEE recorrendo a um estimador (EMQPD).

Os resultados revelam que os participantes do estudo compreendem que a TD, a sustentabilidade ambiental e a internacionalização têm impactos favoráveis nas empresas, corroborando as informações discutidas na literatura.

Adicionalmente, com a análise do MEE, os resultados revelaram que a TD tem efeitos positivos e significativos no desempenho das empresas, na sustentabilidade ambiental e na internacionalização. Ainda assim, esse impacto é mais notável no desempenho das empresas, internacionalização e, por fim, na sustentabilidade ambiental.

Palavras-chave: Transformação Digital, Sustentabilidade Ambiental, Internacionalização, Análise Bibliométrica, Modelo de Equações Estruturais.

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List of abbreviations and acronyms

AGVs: Automated Guided Vehicles

AI Artificial Intelligence

CFI: Comparative Fit Index

CAE: Classificação das Atividade Económicas

DT: Digital Transformation

DWLS: Diagonally Weighted Least Squares

EMQPD: Estimador de Mínimos Quadrados Ponderados Diagonalmente

FA: Factor Analysis

IoT: Internet of Things

IT: information technology

MEE: Modelo de Equações Estruturais

ML: Maximum Likelihood

PCA: Principal Component Analysis

R&D: Research and Development

RMSEA: Root Mean Square Error of Approximation

SEM: Structural Equation Model

SMEs: Small and Medium Enterprises

SRMR: Standardized Root Mean Square Residual

TD: Transformação Digital

TLI: Tucker–Lewis Index

1. Introduction

In the context of an evolving economy with multiple transformations for society and businesses, internationalization, digitalization, and sustainability are three crucial growth paths for firms (Denicolai et al., 2021a; Morua et al., 2015). Businesses constantly face uncertainty and complexity levels due to rapid environmental changes (Ghobadian et al., 2020). Additionally, one of the biggest challenges is the capability of firms to adapt and embrace technological development to maintain a sustained competitive advantage when trends are constantly evolving (Elia et al., 2021). Thus, many researchers agree that incorporating sustainable business practices can contribute to enhancing a firm's value (El Hilali et al., 2020; Ukko et al., 2019).

Industry 4.0 has emerged as a promising technological framework for integrating and expanding manufacturing processes within and between organizations in recent years. The progress and technological advancements in Industry 4.0 will offer practical solutions to the increasing demands for digitization in manufacturing industries. As a result, the number of global enterprises that have embraced the advantages of digitizing their operations through Industry 4.0 has increased. This transition positions them as pioneering digital enterprises in the leading complex industrial ecosystems (PWC, 2016).

In the industrial sector, it is widely recognized that the prevailing economic linear mode of extracting, transforming, and discarding, relies heavily on significant quantities of resources and non-renewable energy sources. This approach has now reached its physical constraints and requires the industrial implementation of sustainable development principles. Therefore, enterprises aiming to compete based on more sustainable principles must realign their focus toward environmental technological innovations, modernizing their production methods by adopting eco-innovations, ensuring the rational utilization of resources, including energy, and preserving the natural environment (Almeida et al., 2016; Yuan et al., 2006).

Regarding internationalization, literature has noted that digital technologies can serve as a complement or aid in accessing international markets (Sinkovics et al., 2013). Digital technologies can play a role in reducing geographical distances, lowering entry costs, and overcoming trade barriers linked to international market participation (Bianchi & Mathews, 2016). By establishing themselves in an international context, companies improve their understanding of foreign markets and potential competitors, taking advantage of an additional avenue for commercial interactions, marketing, and sales. Advances in digital technologies can be used to improve connectivity with business partners, suppliers, distribution networks, and customers while facilitating integration into surrounding global value chains (Jin et al., 2014).

The relationship between DT, environmental sustainability, and internationalization has received less academic attention throughout the years. However, each of these topics is an important research area on its own. Hence, this research aims to explore the impact of DT on environmental sustainability, and internationalization strategy.

To meet the objective, firstly a bibliometric analysis was performed which enables one to investigate the literature of a given domain from a quantitative point of view. Data was collected from the Web of Science database, covering the period from 2014 to 2022. The search query included specific terms related to the topics of interest, such as "digitali*ation or digiti*ation or digital transformation AND internationali*ation AND sustainability". The collected data was downloaded as a plain file and subsequently analyzed using the bibliometric analysis tool called Bibliometrix.

By leveraging Bibliometrix, the authors were able to conduct various analyses and visualizations to explore the scientific production in the field of interest. This included examining the annual growth of publications, analysing country-wise production, identifying the most relevant sources and affiliations, and determining the most globally cited countries.

Additionally, the authors conducted a thematic analysis using techniques such as word cloud and thematic maps to uncover the evolving themes within the literature. The analysis of scientific production, coupled with visual representations and thematic analysis, offers valuable insights into the research landscape, prominent contributors, and emerging trends. These findings lay the foundation for future investigations, guiding researchers towards untapped research areas and opportunities for advancing knowledge in this important and interdisciplinary field.

Secondly, we developed a questionnaire that targeted Portuguese firms based in the north of Portugal and classified by the Portuguese Classification of Economic Activities (known as CAE in Portugal) from 10 to 32 and with an open email. The search resulted in a total of 12 769 enterprises that were sent via email the questionnaire. From the total and after excluding incongruent responses, 296 answers were considered in this study. As for the questionnaire, firstly, inquiries were asked some questions concerning the company and surveyed profile and then several questions to rank on a 5-point Likert scale concerning their knowledge of the three topics of study, the firm's DT journey, and its impact on environmental sustainability and internationalisation strategy.

Based on the responses obtained from the questionnaire, we first conducted a Factor Analysis to evaluate the validity, adequacy, consistency, and reliability of the survey. After that analysis was verified, we proceeded with an SEM, employing a DWLS estimator using the JASP software, which utilizes the Lavern package from R software. This method is widely recognized for analysing multivariate models and is frequently chosen to evaluate the validity of hypothesized models.

Employing an SEM led us to validate all hypotheses formulated and determine that DT has a positive impact on enterprises, environmental sustainability, and internationalisation strategy.

The manuscript is articulated as follows: Section 2 presents the literature review on the impact of DT on environmental sustainability and internationalisation strategy. Section 3 details the research materials and methods employed to gather and examine the data for the Bibliometric Analyses, followed by the main findings. As for Section 4, and similarly to the previous one, we provide a comprehensive overview of the research materials and methods used for data collection and analysis for the SEM, followed by the key findings. Finally, in Section 5 we discuss the key findings, limitations, and future work.

2. Literature Review

2.1 Defining digitization, digitalization, and digital transformation.

As the world witnesses the fourth industrial revolution and the digital transformation of business, often referred to as Industry 4.0 (Ghobakhloo, 2020), governments and industries have become more conscious of its progress and its effect on society (Nascimento et al., 2019).

In concordance, Jafari-Sadeghi et al. (2021) explain that the last decades have been marked by an enormous set of digital technologies, platforms and infrastructures that transformed how people live and work, and the way organizations have been driven to adapt and include technology in their processes.

Hence, the topics "digitization", "digitalization" and "digital transformation" are becoming prominent in the literature (Bican & Brem, 2020).

Digitization is defined as the technical process of transforming analogue information into a digital format (Fors, 2013; Yoo, 2010; Yoo et al., 2010). On the other hand, digitalization is described as the socio-technological process of introducing digitization applications at a social and institutional level (Gomez-Trujillo & Gonzalez-Perez, 2022; Sussan & Acs, 2017). Ritter & Pedersen (2020) mention that digitalization is the effect of digitization on society.

According to Kane (2019) and Verhoef et al. (2021a), DT introduces new business models and digital platforms that enable business improvements in operations and markets. In concordance, Morakanyane et al. (2017) add that it is a process that can stimulate business model operations and create value for clients.

Feroz et al. (2021), enhance the previous ideas by saying that DT is a phenomenon that impacts not only organizations but also society and industries, and Furjan et al. (2020) that DT is inevitable for organizations to survive in the market.

Although it is common in the literature to differentiate the concepts mentioned above, some scholars consider them to be connected. Verhoef et al. (2021) for instance, corroborate this idea by identifying three phases of DT: digitization, digitalization, and digital transformation. The authors state that most literature advocates that digitization and digitalization are incremental phases that support DT. In concordance, Savić (2020) suggests that DT plays an umbrella role for digitization and digitalization as they are a necessary step to an organization's DT.

Firms recognize that DT is necessary and inevitable, however, they still struggle to develop a strategy that enables a full benefit because it requires an evaluation of the firm's processes, services, and level of technology (Eden et al., 2019).

Fitzgerald et al. (2013) and Gupta & Bose (2022) mention that DT requires the integration of digital technologies into all areas of business such as leadership, operations, customer needs and innovation, as well as transforming the way firms operate and create value for stakeholders. DT essentially promotes an innovative workplace culture, increases productivity, and helps leaders predict and plan future goals (Hai et al., 2021).

2.1.1. Digitization Capabilities

When an organization embarks on a DT journey, it needs to establish a global and common system for its processes so they can be implemented through technology standardization, shared infrastructures, integrated data, and efficient business processes (Weill & Ross, 2009).

In Ritter & Pedersen's (2020) study, the authors identified three fundamental skills that represent and enable a firm's digitization capability: data, permission, and analytics.

The first skill concerns data and specifically how it is generated, transmitted, stored, and accessed. The authors state that firms cannot extract commercial value from data if the three phases mentioned do not perform well.

The second capability concerns the permission of firms to use data and it implies legislation, contracts, and society. When it comes to legislation, data needs to be used in agreement with local and international law, which is frequently updated. An example is the introduction of the General Data Protection Regulation in Europe, which required a change in how data was being used (Tankard, 2016).

As for permission related to contracts, data management also needs to be settled with the firm's partners, even if the trade and/or use of data are permitted, as they may be restricted to producers of specific equipment, system operators or service providers. Regarding society's permission, some data handling may be perceived as immoral, as specific data applications may offend the public and raise moral issues.

Finally, it is necessary to analyse, visualize and report to extract insights and valuable information from data. Therefore, Ritter & Pedersen (2020), state that the combination of data, permission and analytics provides an indicator of a firm's overall digitization capability.

The previous authors also indicated some key questions to better comprehend a firm's digitization capability, based on three levels suggested by Minbaeva (2018) that imply that an organization should act on individuals, processes, and structure, as Table 1 resumes.

	Data	Permission	Analytics
Individuals	What kinds and how many employees are working with data generation, transmission, storage, and access for the firm? Which new roles will be needed?	What kinds and how many employees are working with permissions for the firm? Which new roles will be needed?	What kinds and how many employees are working with analytics for the firm? Which new roles will be needed?
Processes	What kinds of data generation, transmission, storage, and access processes are established in the firm?	What kinds of processes related to permissions are established in the firm?	What kinds of processes related to analytics are established in the firm?
Structure	What kind of structure regulates the firm's data generation, transmission, storage, and access?	What kind of structure related to permissions exists in the firm?	What kind of structure governs analytics in the firm?

Table 1: Digitalization Capabilities

Adapted from Ritter & Pedersen (2020, page 4)

2.1.2. Digitalization Capabilities

Concerning digitalization capabilities, Annarelli et al. (2021) describe it as the capability of an organization to combine and control its digital and business resources, digital networks, product innovation, services and processes for organizational learning, customer value creation and manage innovation to ensure a sustained competitive advantage.

Zhao et al. (2022) state that digitalization capabilities enable efficiency in a firm´s processes and resource management, leading to sustainable economic, social, and environmental growth.

In concordance, Porter & Heppelmann (2014) add that digitalization offers new function opportunities, increases reliability and efficiency, and optimizes possibilities.

Based on Teece's (2007) research, which studied the dynamic capabilities necessary to support sustainable business performance, firms should be able to recognize opportunities and threats and know how to take advantage/overcome them. On that note, Annarelli et al. (2021) whose paper consisted of a literature review on digitalization capabilities, were able to gather three dynamic capabilities related to digitalization.

The first one was the capability to recognize opportunities and threats by managing digital ecosystem partnerships. This can be achieved by, for example, the integration of information technology (IT) infrastructures to build higher-order process capability to integrate its physical, financial and information flows with the supply chain partners.

The second capability focuses on the firm's expertise to seize digital capabilities, and it can be achieved by promoting digital processes and taking advantage of opportunities that can generate and propagate innovative ideas (McAfee & Brynjolfsson, 2008). Another example concerns the usage of various resources that enable digital solutions to exchange and process information and automate tasks (Mishra et al., 2007).

Finally, the third capability deals with reshaping digital resources and routines within the firm. Wheeler (2002) explains that this can be attained by choosing and selecting IT resources, making use of economic opportunities linked to promising technologies, investing in business innovations, and reviewing the value for customers.

2.2 From Digitization and Digitalization to Digital Transformation

Gimpel & Röglinger (2015) mention that DT takes place when a firm implements several digitization projects. According to the authors, six action fields determine a successful firm´s DT journey as indicated in Figure 1:

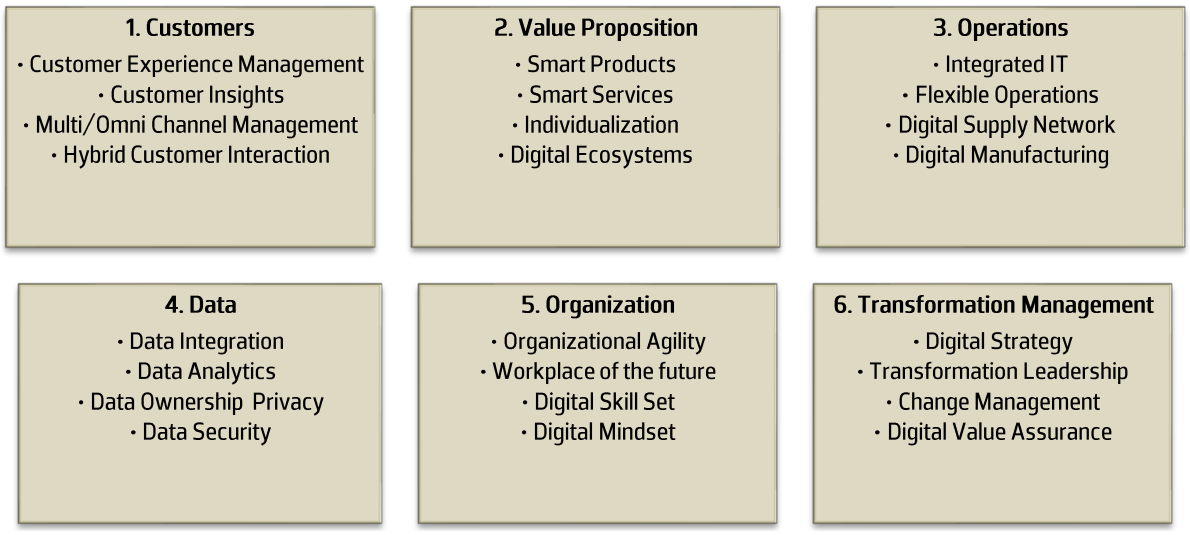


Figure 1: Action fields for a firm´s successful DT

Adapted from Gimpel & Röglinger (2015, page 9)

1. Customers

Digital technologies change customers' perspectives and behaviours in terms of how they acknowledge information, evaluate, and purchase an item. Therefore, companies must provide customers with experiences on a rational, emotional, sensorial, physical, or spiritual level to make them feel involved in their processes (Gentile et al., 2007). As for customer insights, they are crucial to understanding and addressing consumer needs, which then allows a firm to gain a new perception of customer wishes, predict consumer behaviour, personalized products, and services, and eventually improve their experience, satisfaction, and value.

The usage of digital and traditional channels of information forces firms to target their interaction with customers, shaping multi and omnichannel management. Multichannel management, according to Mirsch et al. (2016) is a set of activities that consist of selling products or services to customers through more than one channel. However, these are not connected and are treated separately, therefore, there is no exchange of data across channels. The authors give the example of a retailer with both a physical store and a website, where it is possible to place an order for an item online, but it cannot be returned to the physical store. As for the omnichannel, Verhoef et al. (2015) defined it as the effective management of various available channels and customer touchpoints in a way that maximizes both the customer experience across channels and the performance across those channels.

Finally, digitalization provides new ways of hybrid customer interaction that take place on a strategic, process and system level, which can influence the innovation of products and services and decrease costs (Nüesch et al., 2015).

2. Value Proposition

The constant changes in customer behaviour and rising of digital technologies propose a preference for innovative business and value propositions. Firms can meet this preference by integrating digital innovations into physical products – the so-called smart products. Similarly, through smart services, firms can expand their value proposition by enabling services through digital technologies.

Concerning individualization, this trend brings new opportunities to increase a value proposition. Gimpel & Röglinger (2015) refer that companies should allow customers to participate in their process, by integrating them into, for example, the design process, offering individual services, and customizable products.

The authors add that regarding digital ecosystems, firms, on the one hand, benefit from collaborating and connecting with different partners by joining forces in the innovation process, and on the other hand, customers gain an improved or enhanced product and/or service.

3. Operations

Rapid digitalization is constantly changing the external business environment and one of the main foundations of a firm, but also a challenge is the establishment of an integrated IT infrastructure. Therefore, the information must flow between distinct parts, systems, and networks to provide additional value to a firm.

As for digital supply networks, to maximize the potential of fast digitalization, firms need to create a connected, innovative, and rapid supply network that incorporates all partners, suppliers, and customers. An enabler of quality and efficiency of manufacturing is digital manufacturing which can be achieved through, for example, computer-based processes or intelligent production systems (Gimpel & Röglinger, 2015).

4. Data

Firms must learn how to efficiently absorb and analyse the data and information provided to successfully transform their business digitally. Data integration is one of the key requirements and qualifications to achieve the previous idea and can be accomplished through a consistent and well-organized database. Another aspect is data analytics, which importance relies on using the right techniques to process data since it helps identify behavioural patterns and evaluate ideas, optimise internal operations, and identify new sources of revenue.

Regarding data ownership and privacy, the rights and/or control over data are relevant factors to determine a firm's competitive position. Finally, data security represents one of the main challenges to firms because of strict regulations and consequences in case of data loss (Gimpel & Röglinger, 2015).

5. Organization

Many firms still struggle to manage and meet the demands of new digital services, and to be successful in a constantly evolving digital world, a certain agility is necessary to better identify and implement opportunities. A workplace of the future entails' flexibility and new forms of collaboration, in which the employees are up to date with the latest developments and technologies, leading to a digital skill set. A digital mindset should also be present in a firm's workplace to succeed in its digital transformation journey (Gimpel & Röglinger, 2015).

6. Transformation Management

To decide whether it is necessary to defend or expand a firm's current position on digital technologies, it is necessary to trace a digital strategy that incorporates the organization's vision, aspirations, opportunities, and activities that maximize digital projects. Another important aspect is to define who supervises transforming and defining the firm's digital strategy. However, all

employees must be involved and integrated with the firm's digital transformation journey, hence, change management is a crucial factor. Finally, to better understand and ensure that a firm's efforts are providing positive results, it is needed to evaluate and track the digital value (Gimpel & Röglinger, 2015).

2.3 The Impact of Digital Transformation on Environmental Sustainability

In such a globalized world, firms are pressured both by markets and stakeholders to incorporate sustainable practices to enhance their value and brand image (El Hilali et al., 2020; Neutzling et al., 2018; Ukko et al., 2019). Sustainability refers to a series of social, technological, economic, and environmental changes to foster a resilient system in which the population's needs are met without compromising the future generation (Erős et al., 2022; Estoque, 2020).

According to Goodland, Moldan et al. (2012) state that environmental sustainability aims to improve human well-being by preserving the sources of raw materials used to meet human needs and ensuring that waste is best managed to avoid harm to future generations.

To Hart & Dowell (2011), environmental sustainability in business is shaping a strategy considering environmental, economic, and social factors and adapting production processes to more eco-friendly practices. Denicolai et al. (2021) enhance the previous idea stating that environmental sustainability is an important factor for enterprises in today's economy, and if performed well, it reduces their impact on the environment and guarantees resource availability for future generations.

Amini & Bienstock (2014) and Lamboglia et al. (2018), add that environmental sustainability must incorporate business operations at a strategic and internal level. At a business level, sustainability can be integrated with the adoption of business strategies and activities that meet the firm's and stakeholders' needs and protect, maintain, and enhance human and natural resources, as Ukko et al. (2019) mentioned. To Hart & Dowell (2011), environmental sustainability in business is shaping a strategy considering environmental, economic, and social factors and adapting production processes to more eco-friendly practices.

Demartini et al. (2019) suggest that many companies are relying on Artificial Intelligence (AI), the Internet of Things (IoT) and big data analytics to perform their business practices as a way of reducing carbon emissions and lessening waste to the environment. Additionally, Feroz et al. (2021) did a systematic literature review to identify research trends and future research agendas about DT

and environmental sustainability. Their research revealed that AI, big data, IoT, social media analytics, cloud computing and mobile technologies influence environmental sustainability. As seen in Figure 2, the authors were able to summarize these influences in four categories:

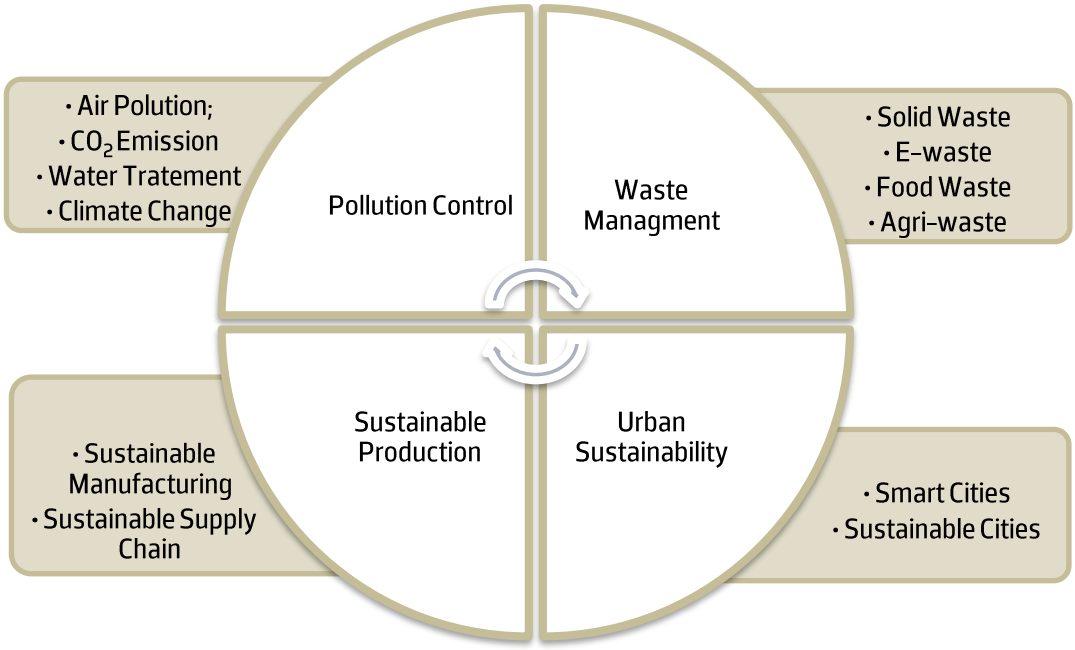


Figure 2: The influence of DT on environmental sustainability

Adapted from Feroz et al. (2021)

Pollution requires particular attention from researchers since it directly affects both the environment and human health (Ancion et al., 2010). Industries like metallurgic and energy are the major sources of air and water pollution and with DT, it is possible to decrease carbon emissions, climate change, and air pollution and manage disasters (Mani & Wheeler, 1998). For example, de Gennaro et al. (2016), mention that the use of big data allows the deployment of green vehicles for future generations by supporting low-carbon transport, which then allows for controlling CO2 emissions. The authors add that the use of big data can reduce risk, costs and harm to the environment.

On the other hand, when it comes to sustainable production, Tsolakis et al. (2014) suggest that if well performed, firms can reduce operational costs, be more lucrative, improve their work safety and reduce their impact on the environment. In this case, Zhang et al. (2017), proposed a model of cleaner production using big data analytics and product life cycle, shifting to more sustainable operations and practices that allow value creation for enterprises.

As for waste management, food waste, agricultural waste and solid waste have a considerable environmental impact on society (Papargyropoulou et al., 2014; Yazdani et al., 2021). In this case,

digital technology, such as AI, is requested by customers to collect and manage all the waste generated by electronic devices (Gu et al., 2017).

Finally, urban sustainability refers to the relationship between society and the ecosystems (Wu, 2014). Both smart cities and sustainable cities are associated with urban sustainability and digitalization. Smart cities, according to Malik et al. (2018), focus on enhancing citizens' well-being, sustainability, and operational efficiency through cutting-edge digital technologies like IoT. On the other hand, sustainable cities sustainably manage resources to improve collective well-being, using technology (Hofstad, 2012). Technologies like mobile internet, AI and big data analysis, improve cities' resources and provide citizens access to better services while reducing their footprint on the environment (Sun & Zhang, 2020).

2.4 The impact of Digital Transformation on Internationalisation

Hagiu & Clipici (2009) state that as globalization and competition are growing, internationalisation is becoming more relevant and crucial for firms around the globe. Hence, internationalisation is considered by many an essential factor for improving firms' growth and performance (Lee et al., 2019; Pereira et al., 2022).

To Beneki et al. (2011) internationalisation is understood as enterprises that are present in one or more foreign markets and do business in an international context. By being present in the international market, firms obtain competitive advantages. With constant change, knowledge flow and globalization, Pereira et al. (2022) state that internationalizing has become a requisite for many firms to survive and keep up with competitors.

The advancements in technology have significantly reduced the obstacles to internationalizing businesses that previously favoured large corporations with ample resources. As a result, small and medium enterprises (SMEs) now have the potential to find internationalisation more feasible and appealing (Pett et al., 2004). Moreover, the ongoing digitalization of the global economy offers opportunities for SMEs to expand their operations globally and achieve scalability (Stallkamp & Schotter, 2021).

In terms of the impact of DT on the internationalisation of businesses, Pereira et al. (2022) mention that if properly incorporated, the capabilities acquired by digital technologies allow firms to establish new internationalisation strategies. To succeed in foreign markets, Hervé et al. (2020) suggest that firms should seek innovation and be proactive and risk-taking to achieve a more successful internationalisation.

Jean et al. (2010) indicated that digital technologies can influence firms' internationalisation and provide smaller firms, the so-called SMEs, the opportunity, and tools to reach international

consumers. Firms with digital technologies can offer customers new ways of interacting with each other and creating value (Brouthers et al., 2016).

Based on Hervé et al.'s (2020) research which conducted an in-depth reading process of five systematic literature reviews acclaimed in the research realm, the authors were able to gather four fields where digitalization supports and accelerates the internationalisation process, as seen in Figure 3.

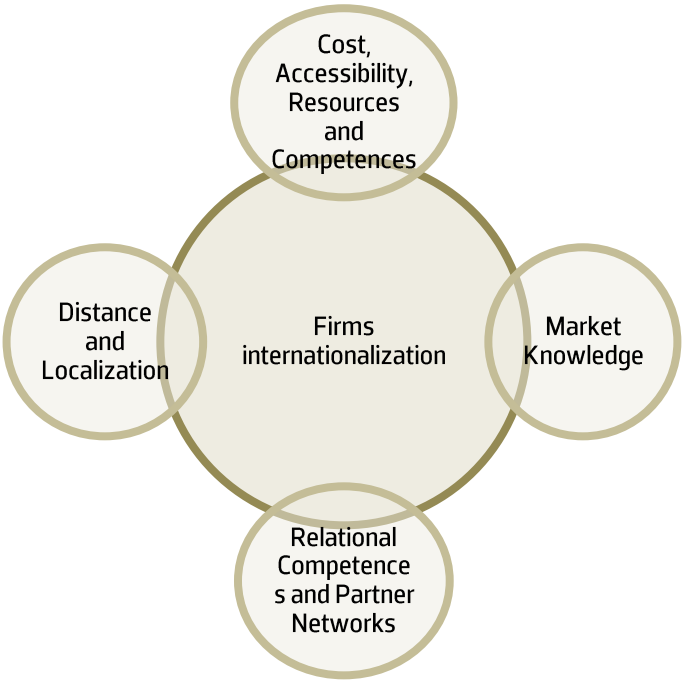


Figure 3: The influence of DT on the internationalisation process

Adapted from Hervé et al. (2020)

Brouthers et al. (2016) and Coviello et al. (2017) are in concordance that digitalization enables enterprises to manage potential costs from operating in foreign markets and manage risk. According to Hervé et al. (2020), technological advances also dematerialized distribution and production channels, allowing firms to lessen transaction costs in foreign markets. Coviello et al. (2017) argue that those digital technologies open a new path in terms of innovation, skill-sharing, and partnership.

Concerning market knowledge, Hervé et al. (2020) refer that a firm's speed of internationalisation differs from firm to firm, as well as its capability to acquire knowledge from foreign markets. With digital technologies, not only is it possible to interact with customers and meet their needs, but enterprises can also conduct market experiments and share them around the globe with potential consumers (Strange & Zucchella, 2017).

When it comes to distance and localization, the main influence of digitalization is the acceleration of the internationalisation process and border dissipation, because it is possible to

manage international activities from the domestic office, access more physically far markets and reduce psychological distances (Strange & Zucchella, 2017).

To finish this section, digitalization also influences networks and the relationship between enterprises and the supply chain. Coviello et al. (2017) state that the market participants are growing and Strange & Zucchella (2017), argued that because of digital technologies, firms tend to involve customers as a source of information and feedback on products. Finally, Coviello et al. (2017) state that digitalization enables firms to access knowledge and consistency to maintain relationships. For it to continue, managers are called in to arrange processes and mechanisms to develop and diversify contacts.

3. Research Methodology: Bibliometric analysis

Bibliometric analysis is a robust methodology used to comprehend and map the collective scientific knowledge within established fields by systematically analysing large volumes of unstructured data. It offers valuable insights and foundations for advancing a field in innovative and significant ways (Donthu et al., 2021).

This methodology enables scholars to obtain a comprehensive overview of the field, identify gaps in knowledge, generate new research ideas, and position their contributions effectively.

For this study, data was collected from the Web of Science database, including specific terms related to the topics of interest, such as "digitali*ation or digiti*ation or digital transformation AND internationali*ation AND sustainability" and covering the period from 2014 to 2022, since 2014 was the first year where all topics were investigated. The search yielded a total of 17 publications, which were all included in the analysis.

The collected data was downloaded as a plain file and subsequently analyzed using the bibliometric analysis tool called Bibliometrix. This tool is widely recognized as an open-source and user-friendly resource that enables quantitative research in scientometrics and bibliometrics. It offers comprehensive functionality and integration, making it a valuable choice for conducting bibliometric studies (Moral-Muñoz et al., 2020).

By leveraging Bibliometrix, the authors were able to conduct various analyses and visualizations to explore the scientific production in the field of interest. This included examining the annual growth of publications, analysing country-wise production, identifying the most relevant sources and affiliations, and determining the most globally cited countries. Additionally, the authors conducted a thematic analysis using techniques such as word cloud and thematic maps to uncover the evolving themes within the literature.

3.1 Data analysis and findings

3.1.1 Scientific production

This analysis section aimed to provide insights into the countries contributing to the research topic, the annual production trends, the most relevant sources and affiliations, and the globally cited documents. By examining these factors, we gain a deeper understanding of the development and global impact of the research in this field.

The annual production allows us to understand the research topics' development over time, the country's production to comprehend the theme´s globality level, and the sources and affiliations to highlight the most relevant ones.

Overall, scientific production increased from 2014 to 2021, reaching its peak in 2021 with six articles, and then decreasing to one article in 2022, as illustrated in Figure 4.

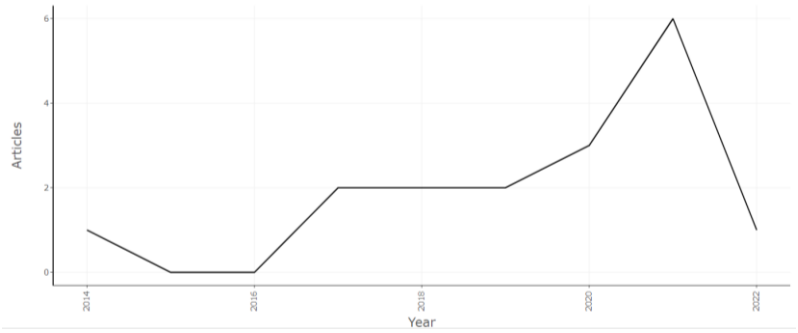


Figure 4: Annual Scientific production

The top three countries that contribute the most to this research topic are Germany (n=10), the USA (n=6), and Portugal (n=5). Figure 5 shows that out of the top ten countries, seven of them are from Europe.

The impact of DT on environmental sustainability and internationalisation strategy remains a niche topic for research with a total of 47 articles from 20 producing countries.

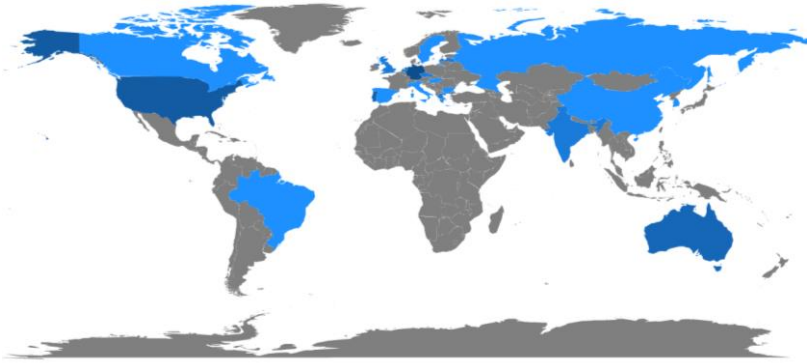


Figure 5: Country´s Scientific production

As for the most relevant sources, the Journal of Cleaner Production occupies the top with five publications, followed by the 12th International Conference of Education Research with one publication as well as Direccion Y Organizacion, as Figure 6 shows.

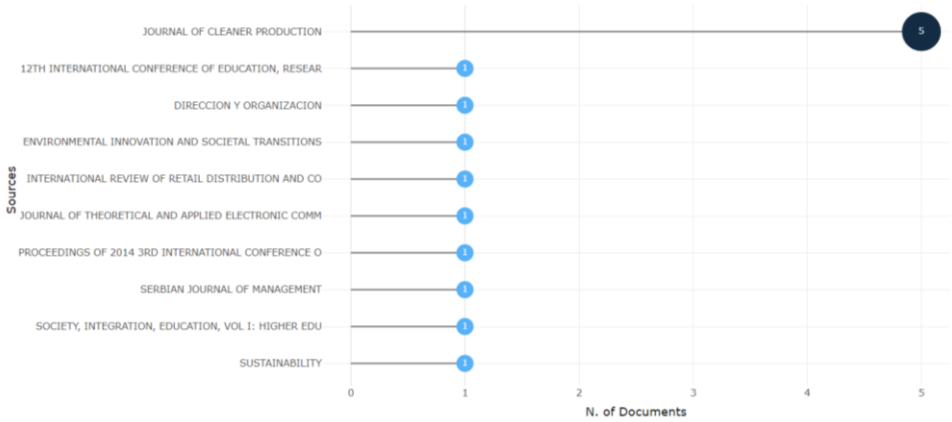


Figure 6: Most relevant sources

Figure 7 illustrates the key organizations that contribute the most to this research, and contrary to the results of the most contributing countries, Arizona State University (n= 7) from the USA is the most productive Academic Institution, followed by Leuphana University Luneburg (n=5) and University of Aveiro from Portugal (n=4).

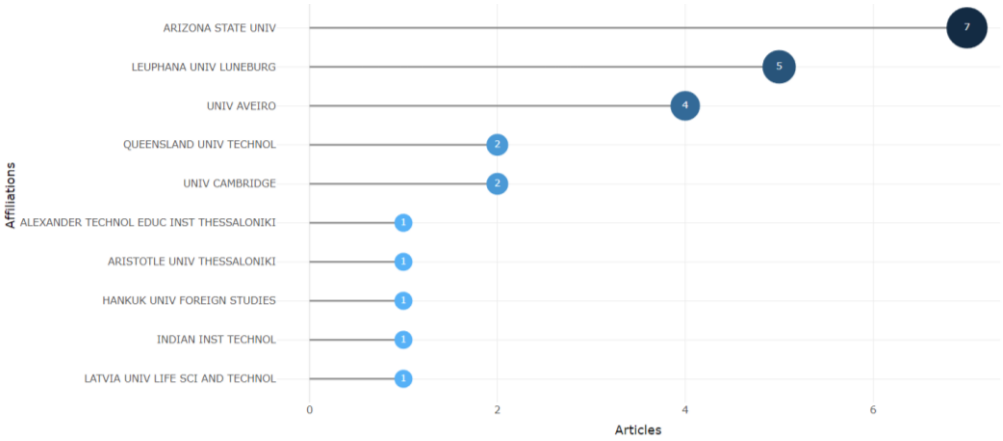


Figure 7: Most relevant affiliations

Finally, concerning the most globally cited documents, Bechtsis et al. (2017) are at the top with 98 citations, followed by Denicolai et al. (2021) with 71 citations and Tumelero et al. (2019), with 56 citations, as seen in Figure 8.

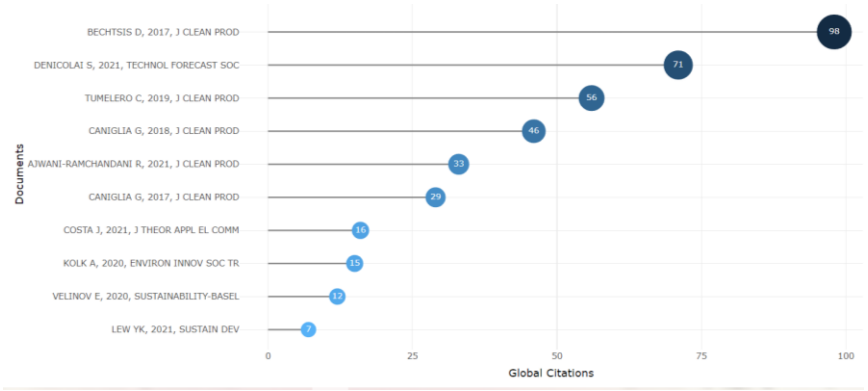


Figure 8: Most globally cited documents

Bechtsis et al. (2017) research discussed the sustainability potential of Automated Guided Vehicles (AGVs) and provided a critical taxonomy of key decisions for facilitating the adoption of AGV systems into the supply chain design and planning. The authors introduced a conceptual tool, the Sustainable Supply Chain Cube (S2C2), that combines sustainable supply chain management with a hierarchical decision-making framework for AGVs.

Furthermore, the authors concluded that AGVs have reached an age of maturity that allows for their utilization towards tackling dynamic market conditions and aligning supply chain management focus with sustainability considerations, and that AGVs can efficiently and effectively execute daily manufacturing and supply chain operations, functioning autonomously and in collaboration with other AGVs, while also interacting with human resources.

Denicolai et al. (2021) research, investigated the relationships between internationalisation, digitalization, and sustainability and concluded that AI readiness positively influences the international performance of SMEs, and that digitalization and sustainability are positively related, but they turn out to be competing growth paths when the firm internationalizes.

Finally, Tumelero et al. (2019) explored the effect of cooperation in research and development (R&D) and eco-innovations on firms' socioeconomic performance. The authors collected data from 221 electrical and electronic manufacturers in Brazil. They were able to conclude that cooperation in R&D and eco-innovations positively influence companies' socioeconomic performance, that knowledge synergies released from cooperation in R&D with heterogeneous agents are advantageous to the introduction of multidimensional types of eco-innovations and that eco-innovations can positively influence both the social and economic performances of companies.

3.1.2 Thematic Analysis and Evolution

In this segment, the authors aim to visualize the word cloud and analyse the thematic map. The first one is a visual representation of a text, that enables one to visualise unstructured text data and get insights on trends and patterns. The second one allows one to visualize a graphical representation of four typologies of themes depending on the quadrant in which they are plotted.

Concerning the word cloud, Figure 9 shows that "internationalisation" (n=5), "impact" (n=3), "performance" (n=3), "business models" (n=2) and "collaboration" (n=2) are the most frequent words when studying the impact of DT on environmental sustainability and internationalisation strategy.

Figure 9: Word Cloud

The findings from the thematic map, as depicted in Figure 10, provide valuable insights into the specific themes that fall within each quadrant. These findings allow us to understand the relative importance and development of these themes within the research field of DT, environmental sustainability, and internationalisation strategy.

Motor themes, located in the upper-right quadrant, represent highly central and dense themes that indicate their significant development and importance within the field. In this case, the motor themes are" performance"," business models", and" technology." These themes are likely to be driving forces in the research domain, attracting considerable attention and research efforts. They play a crucial role in understanding and advancing the understanding of how DT impacts environmental sustainability and internationalisation strategy.

Basic and transversal themes, found in the lower-right quadrant, are highly central but less dense. These themes, namely" internationalisation"," management," and" sustainability," are considered fundamental and applicable across various research areas. They play an important role in shaping and influencing research on DT and its implications for environmental sustainability and internationalisation strategy.

Emerging or declining themes, located in the lower-left quadrant, exhibit low centrality and density. These themes include" impact,"" collaboration," and" determinants." The positioning of these themes suggests that they might be currently gaining or losing prominence within the research field. They may represent emerging areas of investigation or declining topics that are becoming less influential in the context of DT, environmental sustainability, and internationalisation strategy.

Niche themes, found in the upper-left quadrant, are characterized by well-developed internal links (high density) but limited importance to the broader field (low centrality). The niche themes identified in this analysis are" design,"" opportunities," and" science." These themes may

represent specialized or specific areas of research within the broader domain, attracting interest from a relatively smaller subset of researchers or focusing on distinct aspects of the topic.

Overall, the thematic map provides a comprehensive view of the research landscape, highlighting the prominent and evolving themes within the field of DT, environmental sustainability, and internationalisation strategy. This information can guide researchers in identifying the most influential and relevant themes, uncovering research gaps, and identifying potential areas for further exploration and contribution.

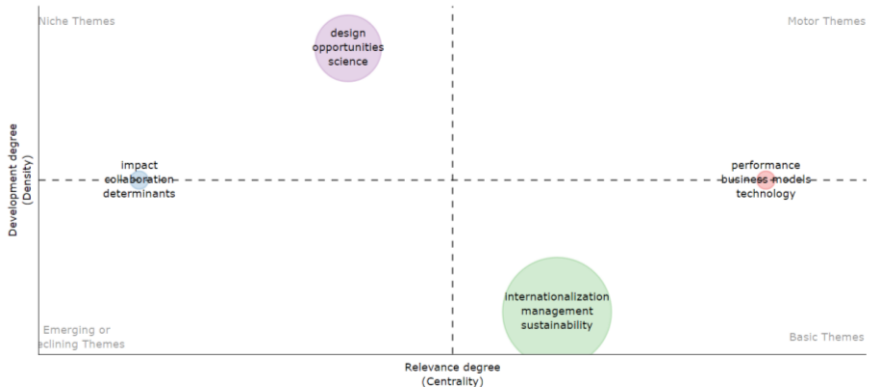


Figure 10: Thematic Map

3.2 Discussion

This paper aims to explore the fronts of research of DT on environmental sustainability and internationalisation strategy. Several key pieces of information can be drawn from this study.

The findings reveal that scientific production in this area has seen a notable increase from 2014 to 2021, reaching its peak in 2021 with six articles. However, it is important to note that the popularity of research in this field has experienced a decline since 2021, indicating a potential shift in focus or the need for fresh perspectives and approaches.

Analysing the top contributing countries, we find that Germany, the USA, and Portugal are at the forefront, with Germany leading with the highest number of contributions (n=10). Furthermore, seven out of the top ten contributing countries are from Europe, indicating the region's active involvement in this research domain. This international perspective underscores the global nature of the topic and highlights the need for collaborative efforts to address the challenges at hand.

Additionally, the identification of the most relevant sources provides insights into the key publications driving research in this field. The Journal of Cleaner Production stands out with the highest number of publications (n=5), followed by the 12th International Conference of Education Research and Direccion Y Organizacion. These sources serve as crucial platforms for disseminating knowledge and fostering discussions on the impact of DT on environmental sustainability and internationalisation strategy.

Examining the most productive affiliations reveals the institutions leading the way in this research domain. Arizona State University from the USA emerges as the most productive academic institution (n=7), followed by Leuphana University Luneburg and the University of Aveiro from Portugal. These institutions demonstrate their dedication to advancing knowledge and contributing to the field through their research output.

The analysis of the most globally cited documents provides insights into the research that has had a significant impact on the field. Notably, the work of Bechtsis et al. (2017) holds the highest number of citations (98), followed by Denicolai et al. (2021) with 71 citations and Tumelero et al. (2019) with 56 citations. These documents have garnered considerable attention and are likely to have shaped subsequent research in the domain.

Moving beyond quantitative analysis, the study also employs visual representations, such as the word cloud and thematic map, to gain a deeper understanding of the research themes and their contributions to the overall growth of the field.

The word cloud analysis highlights" internationalisation," impact," performance," business models," and" collaboration" as the dominant themes in examining the impact of DT on environmental sustainability and internationalisation strategy.

The thematic map further enriches our understanding of the research landscape. It categorizes themes into different quadrants based on their centrality and density. The motor themes are" performance," business models," and" technology," representing driving forces in understanding the impact of DT on environmental sustainability and internationalisation strategy.

The basic and transversal themes include" internationalisation," management," and" sustainability," which are considered fundamental and applicable across various research areas, shaping, and influencing research in the field.

The emerging or declining themes such as" impact," collaboration," and" determinants" indicate ongoing shifts in their prominence within the research field. They may represent emerging areas of investigation or declining topics that are becoming less influential in the context of DT, environmental sustainability, and internationalisation strategy.

Lastly, the niche themes characterized by well-developed internal links (high density) but limited importance to the broader field (low centrality), identified in this analysis are" design,"" opportunities," and" science," indicating specialized or specific areas of research within the broader domain.

Overall, the thematic map provides a comprehensive view of the research landscape, highlighting prominent and evolving themes within the field of DT, environmental sustainability, and internationalisation strategy. These insights guide researchers in identifying influential and relevant

themes, uncovering research gaps, and exploring potential areas for further exploration and contribution.

In conclusion, this study sheds light on the current state of research in DT on environmental sustainability and internationalisation strategy. The analysis of scientific production, coupled with visual representations and thematic analysis, offers valuable insights into the research landscape, prominent contributors, and emerging trends. These findings lay the foundation for future investigations, guiding researchers towards untapped research areas and opportunities for advancing knowledge in this important and interdisciplinary field.

4. Research Methodology: Structural Equation Model with DWLS estimator

4.1 Sample and procedure

An online survey (see Appendix 1) was conducted to collect data among Portuguese companies and their knowledge of the impact of DT on environmental sustainability and internationalisation. The questionnaire was based on the literature presented in Section 2 as well as previous work from Denicolai et al. (2021), Eisner et al. (2022), Pinzaru et al. (2022) and Velinov et al. (2020).

The database used to select the sample of the objective of the study was Sabi. After applying the filters of "state: active companies", "country/region: North of Portugal", "primary codes: 10 to 32" (see Table 2) and "all of the enterprises with an open email", the search returned 12 769 eligible enterprises. The data was collected on the 16th of June 2023.

The 12 769 enterprises were contacted via email (see Appendix 2) with a link that directed them to respond to the questionnaire via Google Forms. Because the response rate was low (2.43%), the email was sent twice to each company from the 18th of June to the 9th of July of 2023. On the 9th of July 2023, a total of 310 responses were collected.

10- Food Industries	22 - Manufacture of rubber and plastic products
11- Beverage Industries	23 - Manufacture of other non-metallic mineral products
12- Tobacco Industries	24 - Manufacture of basic metals
13- Textile Manufacturing	25 - Manufacture of metal products, except machinery and equipment
14- Clothing Industry	26- Manufacture of computer, communications, and electronic and optical products
15- Leather and leather products industry	27 - Manufacture of electrical equipment
16- Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	28 - Manufacture of machinery and equipment
17- Manufacture of pulp, paper and paperboard and articles thereof	29 - Manufacture of motor vehicles, trailers, semi-trailers, and components for motor vehicles

18 – Printing and reproduction of recorded media	30 – Manufacture of other transport equipment
19 – Manufacture of coke, refined petroleum products and fuel agglomerates	31 – Manufacture of furniture and mattresses
20 – Manufacture of chemical products and man-made fibres, except pharmaceutical products	32 – Other manufacturing
21 – Manufacture of basic pharmaceutical products and pharmaceutical preparations	

Table 2: Sectors of Activity chosen for the study.

In the first part of the survey, the inquiries were asked some questions concerning the enterprise that they are working for such as the sector of activity, year of foundation, dimension, type, job position and time experience. Then, inquiries ranked on a 5 Likert scale (1- Strongly disagree, 2- Disagree, 3- Neither agree nor disagree, 4- Agree and 5- Strongly agree) several questions concerning their knowledge and familiarity of the concept and applicability of DT, environmental sustainability, and internationalisation within the firm.

The research methodology employed SEM through JASP software (Version 0.17.3), which makes use of the lavaan package (Rosseel, 2012) from the R project. Specifically, the robust weighted least squares estimator, known as DWLS recommended by Muthén (1993), was utilized.

The DWLS method relies on the weighted least squares estimator, also referred to as the asymptotic distribution-free estimator, with polychoric correlations as input to generate the asymptotic covariance matrix.

Empirical studies have demonstrated that this estimator outperforms the widely used maximum likelihood (ML) estimation method in SEM, especially when handling ordinal variables, as seen in the variables under scrutiny in this study (Li, 2016).

Indeed, treating ordinal observed variables as continuous can compromise the precision and accuracy of model parameter estimates, potentially leading to erroneous scientific conclusions based on empirical data (Li, 2016).

Hence, the hypotheses to test are:

Hypothesis 1 (H1): DT positively impacts enterprises.

Hypothesis 2 (H2): DT positively impacts environmental sustainability.

Hypothesis 3 (H3): DT positively impacts internationalisation.

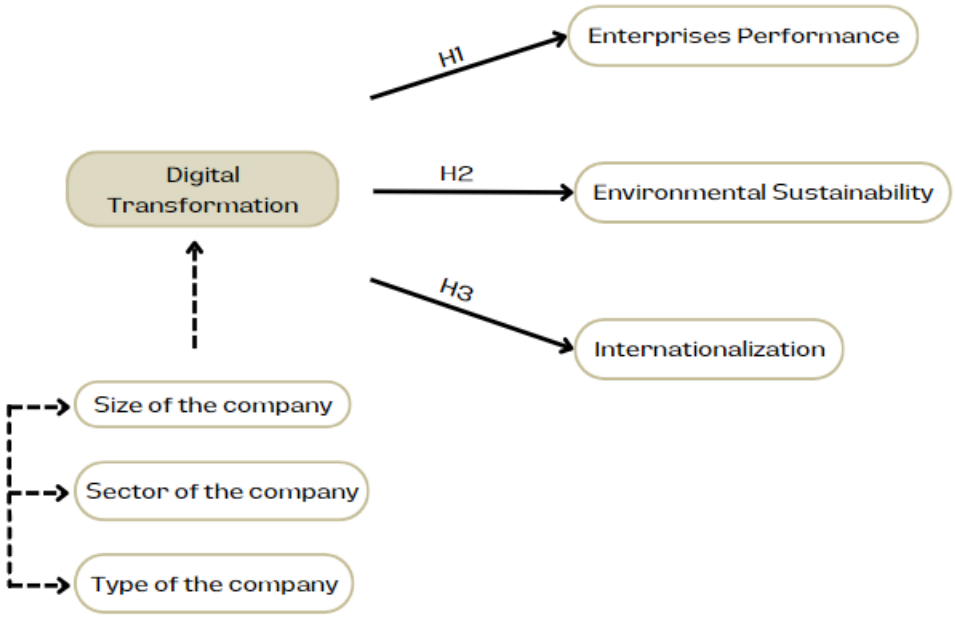
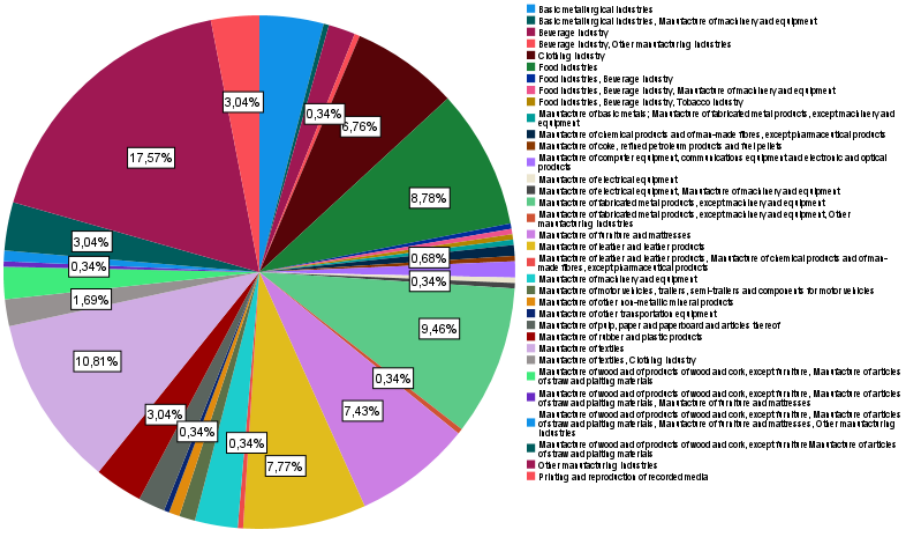


Figure 11: Hypotheses Model

4.2 Descriptive Statistics

After sending the survey via email to a total of 12 769 enterprises, 310 answers were obtained, and 14 were eliminated since some of them were incongruent or missing, leaving us with a total of 296 final responses to analyse.

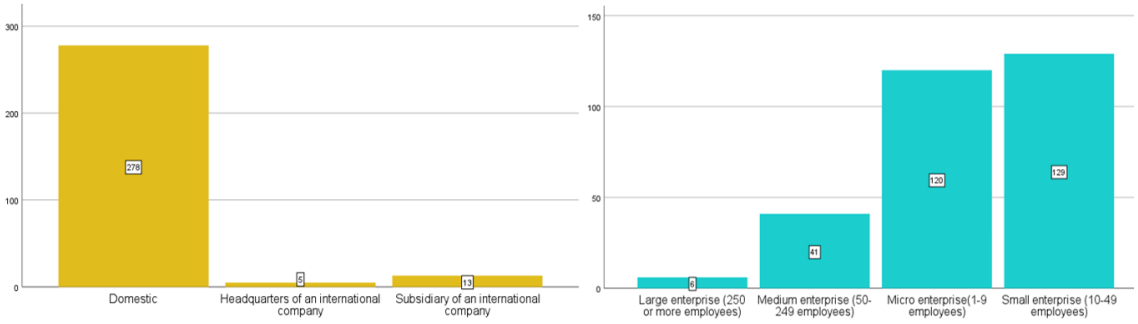
The results show that the sector of activity most represented from the 296 enterprises is other manufacturing industries with 17,57%, manufacture of textiles with 10,8% and manufacture of fabricated metal products, except machinery and equipment with 9,5%, as Graph 1 shows.



Graph 1: Sector of Activity

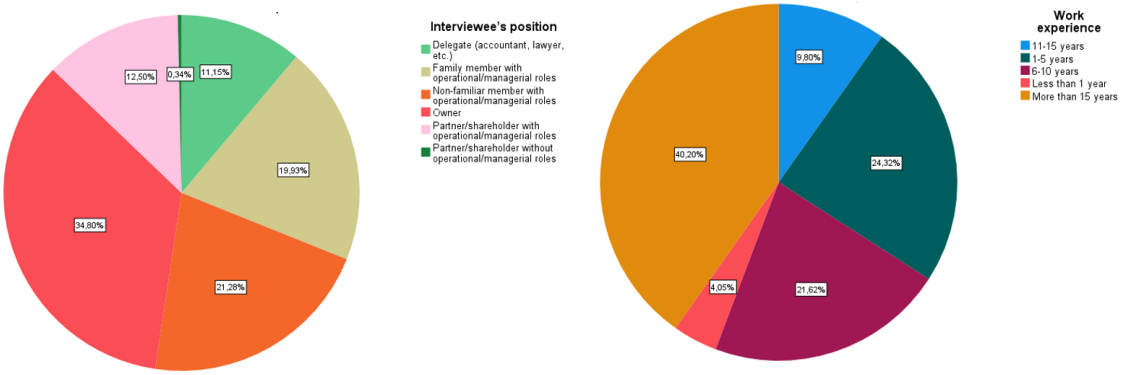
As for the year of foundation or acquisition of the enterprise, the average is 1999,18, the oldest from 1902 and the latest was formed in 2022.

Regarding the type and size of the companies, the vast majority (278 of 296) are domestic, small, and micro companies (129 and 120 out of the total, respectively) as Graph 2 reveals.



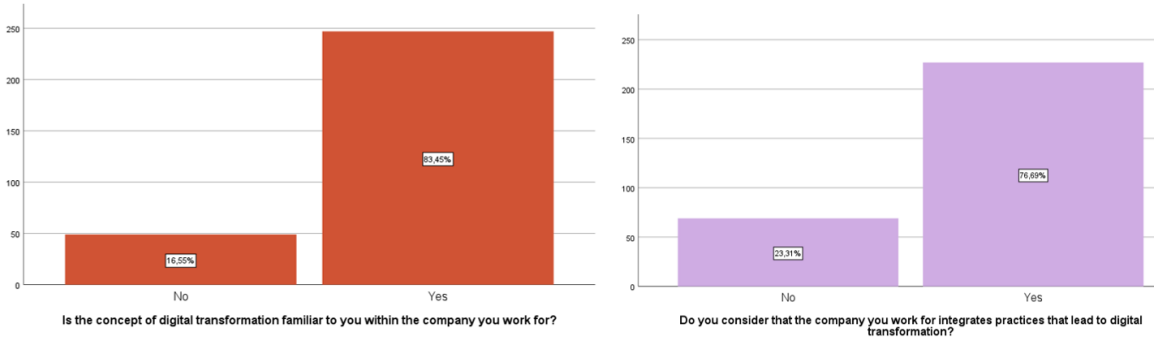
Graph 2: Type and size of the companies

Concerning the surveyed position (see Graph 3), 34,8% of the answers were given by the owners of the companies, 21,28% by non-familiar members with operational/managerial roles and 19,93% by family members with operational/managerial roles. As for their years of experience in the current position, 40.2% of the enquiries have more than 15 years of experience, 24.3% have 1 to 5 years of experience and 21.6% have 6 to 10 years of experience.



Graph 3: Surveyed position and work experience

Regarding the familiarity with the DT concept within the firms, the vast majority (83,45%) responded positively to the question "Is the concept of digital transformation familiar to you within the company you work for?" and 16.55% negatively. However, when asked their opinion of whether the company that they work for integrates practices that lead to DT, 76.7% positively and 23.3% negatively (see Graph 4).



Graph 4: Surveyed familiarity and applicability with the DT concept

Additionally, the inquiries were given some questions to rank on a 5-point Likert-type scale from 1 (Strongly disagree) to 5 (Strongly agree) concerning their agreement or not on DT's role in their enterprise.

Approximately 35.5% of respondents believe that their company provides them with resources and opportunities to acquire skills necessary to leverage digital trends, while 28% expressed neutrality on this matter, and 22.6% strongly agreed. In response to inquiries about their company's acknowledgement of digital technologies as an opportunity, 43.2% agreed, 32.8% strongly agreed and 16,6% neither agreed nor disagreed. Lastly, regarding satisfaction with the current position of their enterprise concerning digital trends, 33.4% of the total inquiries agreed that they are satisfied, 30.1% were neutral and 18.2% strongly agreed.

Regarding environmental sustainability, 82.4% of all inquiries believe that the company they are employed by possesses a strategy and/or policy aimed at mitigating their environmental impact. In comparison, 17.6% provided a negative response. Additionally, 83.4% consider environmental sustainability to be part of the company culture and 16.6% don't.

Continuing from the previous inquiry, participants were once more presented with questions to assess their level of agreement, ranging from 1 (Strongly disagree) to 5 (Strongly agree), regarding the significance of environmental sustainability within their organization. About the incorporation of sustainability practices into their daily tasks, 32.4% affirmed that their company offers them guidance, 27.4% remained neutral, and 17.9% strongly agreed. In addition, 35.8% of the respondents agreed that their manager encourages them to engage in sustainable actions and behaviours in the workplace while 22% strongly agreed and 22% were neutral to this statement. However, lastly, while 36.8% agreed that the sustainable efforts align with the overall strategy of their company, 26% were neutral and only 19.9% strongly agreed.

Finally, about internationalisation, of all firms, 64.5% have an international presence and 35.5% don't. Of the firms that internationalize, 19.9% of the responses have a share of foreign sales between 70 to 100%, 18.9% between 0 to 10% and 9.8% between 30 to 50%. From the total of the

respondents, the vast majority (95.6%) agree that DT combined with internationalisation is beneficial for companies.

As per the previous analysis, respondents were asked to rank from 1 (Strongly disagree) to 5 (Strongly agree) concerning their agreement or not on DT's impact on internationalisation. The first statement was related to the new ways of interacting and creating value that digital technologies allow firms to offer to customers, 48.6% of the participants agreed with the statement, 38.5% strongly agreed and 8.8% responded neutrally. Secondly, 48% agreed and 35,1% strongly agreed that DT enables companies to manage risks and operational costs in foreign markets while 13,2% responded neutrally. When questioned about whether they viewed technological advancements as a facilitator for reducing material usage in distribution and production channels, 48.6% agreed, 31.1% strongly agreed, and 16.6% expressed a neutral stance regarding its ability to help companies cut transaction costs in international markets.

Additionally, 49% of the respondents agree that digital technologies open a new path for innovation, skills sharing and partnership while 38,5% strongly agreed and 8,8% were neutral. Furthermore, and with a very close percentage, 44.3% of the surveyed agree that digital technologies allow companies to better interact with customers and meet their needs, 41.9% strongly agreed and 10.8% responded neutrally. Additionally, when introduced to the potential of conducting market research experiences and sharing them globally through digital technologies, 49,3% of the participants agreed, 36,8% strongly agreed and 10,8% were neutral. Finally, at remarkably similar percentages, 42.2% strongly agreed and 41.9% agreed that digital technologies expedite the internationalisation process, granting access to more distant markets. Meanwhile, 12.5% responded neutrally.

4.2.1 Preliminary analyses

To test the consistency or reliability of a set of survey items, Cronbach introduced Cronbach´s Alpha coefficient (α). It ranges from 0 to 1, with higher values indicating higher agreement between items (Leontitsis & Pagge, 2007).

In this case, α is superior to 0,9 in all hypotheses. H1 is 0,922, H2 0,903 and H3 0,959, indicating that response values for each participant across a set of questions are consistent.

Reliability Test	H1	H2	H3
Cronbach´s Alpha	0,922	0,903	0,959

Table 3: Reliability Test

Maroco (2007) defines factor analysis (FA) as an exploratory data analysis technique that intends to discover and analyse the composition of a set of interrelated variables to construct a

measurement scale for factors that in some way influence the original variables. To study the impact of DT on enterprises, environmental sustainability and internationalisation, an FA was performed to validate or not, H1, H2 and H3.

Towards obtaining the results, the extraction method used was the Principal Component Analysis (PCA) and the rotation method was Varimax with Kaiser Normalization.

The common factors retained were those with an eigenvalue > 1, in agreement with the Scree Plot and the percentage of variance retained. According to the previous author, using a single criterion can lead to the retention of more/fewer factors than those relevant to describe the latent structure. To assess the validity of the factor analysis, the KMO criteria were used with the ranking criteria defined by the author.

Firstly, to justify the usage of FA, three assumptions must be validated: Normality, Linearity and Homoscedasticity. Considering that the sample is ≥ 30, we can assume that according to the Central Limit Theorem (CLT), all variables follow a normal distribution.

Since the variances/standard deviations are in the same range, homoscedasticity can be assumed (see Appendix 3). Finally, for the significance level of 0,05, all the correlations, are significant at this level, thus justifying the use of the FA (see Appendix 4).

The KMO statistic is 0,891 for H1 therefore, and according to Maroco (2007), since 0,8 < 0,891 < 0,9, there is good adequacy of the FA; for H2, KMO is 0,760, since 0,7 < 0,760 > 0,8, there is average adequacy of the FA; for H3, KMO is 0,931 and since 0,9 < 0,931 > 1, there is excellent adequacy of the FA.

For Bartlett's Test of Sphericity, the $\chi 2$ statistic is 1065,627, 842,380 and 2212,108 and the p-value is < 0,001, <0,001 and 0,000 for H1, H2 and H3 respectively, thus the null hypothesis H0: correlation matrix is equal to the identity matrix is rejected. Therefore, according to Silva et al. (2017), it is possible to conclude that the correlation matrix is significantly different from the identity matrix, so it is adequate to run an FA (see Table 4).

	H1	H2	H3
KMO	0,891	0,760	0,931
Bartlett's Test	1065,627	842,380	2213,108
P-Value	<0,001	<0,001	0,000
Total variance explained	76,300	77,443	80,462

Table 4: Assumptions validation for FA

As for the Anti Image Matrix, since all variables are above 0,5, removing any variable from the study is unnecessary (see Appendix 5).

With the PCA method and according to the rule of thumb for extracting factors with eigenvalues greater than 1, in line with the scree plot, it is suggested that one factor explains 76.3% of the total variance extracted in H1, 77,44% in H2 and 80,46% in H3 (see Appendix 6).

The communalities explain the total variance of the original variable by the common factors. Note that the percentage of the variance of each variable explained by the common factors extracted is higher than 50% for all variances in all hypotheses (see Appendix 7).

In H1, the variable "Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders" has the most in common with the other variables, and "Digital transformation impacts businesses, society and industries" the least.

As for H2, the variable "The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society" shares the greatest similarities with the other variables and "The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment" the least.

Finally, in H3 "Digital technologies open a new path in terms of innovation, skills sharing and partnerships" exhibits the strongest resemblances to the other variables, and "Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets" the least.

When analysing the Rotated Component Matrix, all the variables in H1, H2 and H3 are represented in one factor, which indicates that the variables are highly correlated (see Appendix 8).

4.2.2 Hypothesis testing

The hypotheses were tested through SEM and because the respondents' previously ranked questions on a 5-point Likert-type scale from 1 (Strongly disagree) to 5 (Strongly agree), which are ordinal categorical endogenous variables, the most widely used ML estimation was not appropriate for SEM in this study.

On that note, Mîndrilă (2010) claims that diagonally weighted least squares (DWLS) estimation yields a more exact parameter estimate and a more stable model fit than ML when dealing with ordinal data. Consequently, the hypotheses were examined using SEM with DWLS estimation, incorporating robust standard errors, and employing a scaled and adjusted test statistic. The model is composed of three latent variables: enterprise performance, environmental sustainability, and internationalisation, and three control variables: the size, sector of activity and

type of the company. The control variables were added to prevent the manipulation of latent variables. Controlling these variables helps increase the internal validity of the experiment, making it more likely that the results accurately represent the relationship between the variables being studied. Thus, the model's estimation error is no longer due to the absence of information at the company level, such as size, sector of activity and type. It serves to remove unexplained variability (see Figure 12).

Various fit indices were employed to assess the model's adequacy. The incremental fit indices, comparative fit index (CFI) and Tucker–Lewis index (TLI) indicate an optimal fit when their values are greater than 0.95 (Kang & Ahn, 2021). As for the parsimony fit index, the Root Mean Square Error of Approximation (RMSEA) suggests a good fit when its value is below 0.08 (Hu & Bentler, 1999). Furthermore, a suggested cutoff value of 1.0 for the DWLS based on the Standardized Root Mean Square Residual (SRMR) is used to identify good models, particularly when the sample size (N) is greater than or equal to 250, as proposed by (Yu, 2002).

	$\chi 2$	P-value	CFI	TLI	RSMEA	SRMR
Model 1	297.081	<.001	0.999	0.993	0.046	0.058

Table 5: Goodness of fit indices

Despite the significant result obtained from the chi-square goodness-of-fit statistic, it has come to the attention of researchers that this test tends to be sensitive when dealing with sample sizes exceeding 200, as discussed by Leong et al. (2013). However, all other model fit indices have met the recommended thresholds, indicating that the structural model aligns well with the collected data.

Based on the SEM analysis, enterprise performance (β = 0.405, p = <0.001), environmental sustainability (β = 0.267, p = <0.001), and internationalisation (β = .273, p = .001) had positive and significant direct effects on DT. Hence, H1, H2 and H3 were validated.

Hypotheses	Est.	S. Est.	SE	p	Validation
H1	0.418	0.405	0.039	<.001	✓
H2	0.253	0.267	0.035	<.001	✓
H3	0.294	0.273	0.032	<.001	✓

Est.: parameter estimate; S. Est.: standardized estimate of parameter; *SE*: standard error

Table 6: SEM analysis

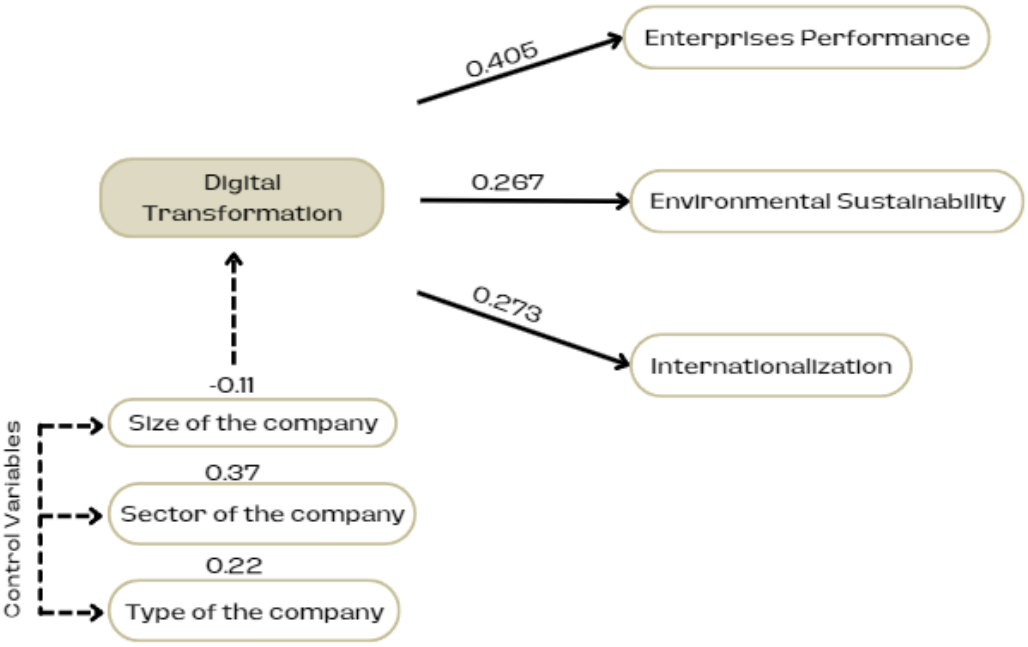


Figure 12: Summary of SEM results

4.3 Discussion

This study examined the impact of DT on enterprises' performance, environmental sustainability, and internationalisation by conducting an SEM.

Firstly, we analysed the results gathered from the 296 final responses and were able to characterize our sample from the sector of activity, year of foundation/acquisition, size, and type of the company, as well as the surveyed position and work experience. Subsequently, participants in the investigation were questioned about their familiarity and agreement levels regarding certain statements related to the study topics.

In general, survey participants acknowledge that the concept of DT is well-known within their organization, and the company implements practices conducive to DT. Additionally, respondents express contentment with their company's current standing about digital trends. They believe that the company equips them with the necessary resources and opportunities to acquire skills for leveraging digital trends. Furthermore, they feel that their firm recognizes digital technologies as a valuable opportunity.

Concerning environmental sustainability, most respondents are confident that their employing company has a strategy or policy in place to reduce its environmental impact. They also believe that environmental sustainability is embedded in the company culture. Moreover, respondents appreciate the guidance provided by their company in integrating sustainability practices into their daily tasks. They feel encouraged by their managers to engage in sustainable actions at work, and they recognize that these efforts align with the company's overall strategy.

Regarding internationalisation, most surveyed companies have a global presence. Respondents understand the synergy between DT and internationalisation, recognizing its advantages for businesses. They acknowledge that digital technologies enable companies to offer innovative ways for customer interaction and value creation. DT also helps in managing risks and operational costs in foreign markets and facilitates the reduction of material usage in distribution and production channels, thereby reducing transaction costs in international markets. Additionally, respondents perceive that digital technologies open avenues for innovation, skills sharing, partnerships, and enhanced customer interaction. They also recognize the potential of conducting global market research experiences through digital technologies, which expedite the internationalisation process and provide access to more distant markets.

Afterwards, we performed an FA to assess the questionnaire's reliability and consistency by testing its assumptions of normality, linearity, and homoscedasticity. As all these assumptions were confirmed, we proceeded to employ SEM to test the formulated hypotheses.

Based on the SEM results, findings reveal that DT has a positive impact on enterprises, environmental sustainability, and internationalisation. The standardized parameter estimate for enterprise performance is $\beta = 0.405$, for environmental sustainability is $\beta = 0.267$ and for internationalisation strategy $\beta = 0.273$. This indicates that DT has a larger influence on enterprise performance, followed by internationalisation strategy and environmental sustainability.

The observed pattern can be explained by various factors. Firstly, DT leads to immediate operational enhancements, driving improvements in efficiency, productivity, and customer satisfaction. These enhancements have a direct and positive impact on the overall performance of the enterprise. Secondly, DT facilitates global expansion initiatives by enabling international outreach through online platforms and digital marketing strategies. This capability significantly contributes to the success of internationalisation efforts, allowing businesses to expand their presence in global markets.

Additionally, DT promotes cost efficiency and resource optimization within organizations. By enabling the smart allocation of resources, it reduces operational costs and minimizes wastage. This efficiency not only reinforces performance but also aligns with environmental sustainability goals by controlling resource wastage and energy consumption.

Furthermore, DT fosters a culture of innovation and adaptability within companies. This innovation enables businesses to quickly adapt to evolving market demands, supporting both internationalisation efforts and sustainable practices within the business ecosystem. Early adoption of DT provides a competitive edge in the market. Businesses at the forefront of DT implementation enhance their overall performance, enabling smoother international expansions and supporting

sustainable practices. This advantage in the market landscape fortifies their position in the global arena.

Strategically integrating DT with organizational objectives yields profound impacts. When DT aligns with strategic goals, it creates a cooperative effect, positively influencing performance, internationalisation activities, and sustainability initiatives. This strategic alignment strengthens the overall impact of DT on the business ecosystem.

In summary, the influence of DT is both interconnected and multifaceted. Its ability to enhance operational efficiency, facilitate global expansion, and promote sustainable practices aligns with the observed patterns in the study. Through these various channels, DT emerges as a transformative force, driving positive change and growth within organizations.

Hypothesis 1 evaluated the effect of DT on enterprise performance and the results revealed DT positively influences an enterprise's performance (β = 0.405, p = <0.001). These results show concordance with previous work from Verhoef et al. (2021b) and Zakharov et al. (2022).

Hypothesis 2 measured the impact of DT on environmental sustainability and results show a positive influence played by DT on environmental sustainability (β = 0.267, p = <0.001). These findings are also in agreement with the results from some of the earlier studies from Denicolai et al. (2021), Feroz et al. (2021) and Gomez-Trujillo & Gonzalez-Perez (2022).

Finally, Hypothesis 3 assessed the influence of DT on internationalisation. Outcomes showed a positive impact of DT on internationalisation (β = 0.273, p = .001). Results are in concordance with Elia et al. (2021) and Pereira et al. (2022) research.

5 Conclusions

This work has investigated the impact of three main topics: DT, environmental sustainability, and internationalisation.

Since entering the globalization era, a new realm of opportunities for businesses has begun. With digitalization, a new way of doing business was introduced enabling business improvements both in operations and markets such as flexibility and cost reduction. While firms have access to new opportunities to explore new markets, consumers also have access to different marketplaces and are becoming more demanding and conscious of what they are purchasing, therefore, firms have been pressured to incorporate sustainable practices.

Our findings with the Bibliometric Analysis provided valuable insights into the present research landscape concerning DT's impact on environmental sustainability and internationalisation strategies by examining the scientific production, utilizing visual aids, and conducting thematic analysis, the research illuminated the key players and emerging trends in the field. These discoveries serve as a stepping stone for future research, directing scholars towards unexplored areas of study and opportunities to further our understanding in this critical and multidisciplinary domain.

Secondly, the survey allowed us to understand the knowledge of Portuguese firms on the three topics of research. The responses from the participants in the survey are consistent with the main discoveries outlined in the literature discussed in the preceding chapters. Overall participants generally recognize their organization's familiarity with DT and the implementation of DT practices. They are satisfied with their company's approach to digital trends and feel well-equipped with resources and opportunities for digital skills development. Additionally, respondents believe their company views digital technologies as valuable opportunities.

Concerning environmental sustainability, most respondents are confident in their company's environmental strategies and policies. They perceive environmental sustainability as an integral part of the company culture and appreciate the guidance provided in integrating sustainability into their daily tasks. Managers encourage sustainable actions, aligning with the company's overall strategy.

In terms of internationalisation, surveyed companies have a global presence. Respondents understand the synergy between DT and internationalisation, recognizing its business advantages. Digital technologies enable innovative customer interactions, risk management, and cost reduction in foreign markets. Respondents also see DT's potential in fostering innovation, skills sharing, partnerships, and global market research experiences, facilitating international expansion to distant markets.

Utilizing SEM with a DWLS estimator enabled us to quantitatively explore the interconnections among the three research areas. SEM is a statistical method employed for examining and deducing causal relationships among variables, allowing for the simultaneous analysis of intricate relationships involving multiple variables. DWLS is frequently applied in SEM when handling survey data with responses recorded on Likert scales. Its use ensures more precise parameter estimates and model fit indices, enhancing the reliability of conclusions regarding data relationships, particularly when dealing with ordinal/categorical data.

Results revealed that DT positively impacts a firm's performance, environmental sustainability, and internationalisation. The standardized parameter estimates reveal that DT has the most significant influence on enterprise performance (β = 0.405), followed by internationalisation strategy (β = 0.273), and environmental sustainability (β = 0.267).

Several factors can account for the observed pattern. DT delivers immediate improvements in efficiency, productivity, and customer satisfaction, directly boosting overall enterprise performance. It enables global expansion through online platforms, enhancing international outreach and supporting internationalisation efforts. Additionally, DT optimizes resources, reducing operational costs and waste, and aligning with environmental sustainability goals. DT fosters innovation, aiding quick adaptation to market demands, and supporting internationalisation, and sustainable practices. Early adoption of DT provides a competitive edge, facilitating international expansions and sustainable initiatives.

When aligned with organizational objectives, DT positively impacts performance, internationalisation, and sustainability, strengthening its transformative influence on businesses. In summary, DT's impact is interconnected and multifaceted, enhancing efficiency, global reach, and sustainability within organizations.

Nonetheless, it's important to note that this study does have certain limitations, firstly concerning the bibliometric methodology. Specifically, the analysis was restricted to the past 8 years, and this limitation arose from the reliance on a single database, Web of Science. To mitigate these constraints, future research endeavours may benefit from exploring alternative databases, such as Scopus. Moreover, regarding the sample size since only 310 responses from a total of 12 769 enterprises surveyed and the fact that only one year's data was collected, which is why in the future we plan to compare data collected annually to make a longitudinal analysis. Additionally, it would also be interesting to broaden the research to other sectors of activity, and geographical areas.

Still, our study paints a picture of potential future scenarios and sets the stage for a fresh research agenda built upon the interconnectedness of the three fundamental growth pathways embraced by firms in today's economies: DT, environmental sustainability, and internationalisation.

Additionally, this work presents an innovative methodology with the employment of an SEM with a DWLS estimator. In the literature that relates DT, environmental sustainability, and internationalisation in section 3, the authors Fayos et al. (2023), Schleiden & Neiberger (2020) and Tumelero et al. (2019) employed an SEM with a Partial Least Squares estimator.

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7 Appendix

Appendix 1: Questionnaire sent to the enterprises.

O impacto da Transformação Digital na Sustentabilidade Ambiental e na Internacionalização das empresas.

Este questionário insere-se numa investigação no âmbito de uma tese de Mestrado em Gestão e Internacionalização de Empresas. O seu contributo é valioso para estudar o conhecimento das empresas portuguesas acerca dos conceitos de Transformação Digital, Sustentabilidade Ambiental e Internacionalização, e do impacto que estes três conceitos têm entre si.
Os dados recolhidos serão tratados confidencialmente garantindo o anonimato.
O tempo estimado de preenchimento é de 6 minutos.

* Indica uma pergunta obrigatória

Secção sem título

1. Perfil da Empresa e do Entrevistado

1. 1.1. Qual o setor de atividade em que se insere a empresa? *

Marcar tudo o que for aplicável.

- [ ] Indústrias Alimentares;
- [ ] Indústria das Bebidas;
- [ ] Indústria do tabaco;
- [ ] Fabricação de têxteis;
- [ ] Indústria do vestuário;
- [ ] Indústria do couro e dos produtos do couro;
- [ ] Indústrias da madeira e da cortiça e suas obras, exceto mobiliário; fabricação de obras de cestaria e de espartaria;
- [ ] Fabricação de pasta, de papel e cartão e seus artigos;
- [ ] Impressão e reprodução de suportes gravados;
- [ ] Fabricação de coque, produtos petrolíferos refinados e de aglomerados de combustíveis;
- [ ] Fabricação de produtos químicos e de fibras sintéticas ou artificiais, exceto produtos farmacêuticos;
- [ ] Fabricação de produtos farmacêuticos de base e de preparações farmacêuticas;
- [ ] Fabricação de artigos de borracha e de matérias plásticas;
- [ ] Fabrico de outros produtos minerais não metálicos;
- [ ] Indústrias metalúrgicas de base;
- [ ] Fabricação de produtos metálicos, exceto máquinas e equipamentos;
- [ ] Fabricação de equipamentos informáticos, equipamento para comunicações e produtos eletrónicos e óticos;
- [ ] Fabricação de equipamento elétrico;
- [ ] Fabricação de máquinas e de equipamentos;
- [ ] Fabricação de veículos automóveis, reboques, semi reboques e componentes para veículos automóveis;
- [ ] Fabricação de outro equipamento de transporte;
- [ ] Fabrico de mobiliário e de colchões;
- [ ] Outras indústrias transformadoras.

2. 1.2. Ano de fundação/ aquisição da empresa *

3. 1.3. Dimensão da empresa *

Marcar apenas uma oval.

- ◯ Microempresa (1-9 colaboradores);
- ◯ Pequena empresa (10-49 colaboradores);
- ◯ Média empresa (50-249 colaboradores);
- ◯ Grande empresa (250 ou mais colaboradores).

4. 1.4. Tipo de empresa *

Marcar apenas uma oval.

- ◯ Doméstica;
- ◯ Subsidiária de uma empresa internacional;
- ◯ Sede de uma empresa internacional.

5. 1.5. Posição do entrevistado. *

Marcar apenas uma oval.

- ◯ Proprietário;
- ◯ Membro da família com funções operacionais/de gestão;
- ◯ Membro não familiar com funções operacionais/de gestão;
- ◯ Sócio/acionista com funções operacionais/ de gestão;
- ◯ Sócio/acionista sem funções operacionais/ de gestão;
- ◯ Delegado (contabilista, advogado, etc.).

27/09/23, 22:48 O impacto da Transformação Digital na Sustentabilidade Ambiental e na Internacionalização das empresas.

6. 1.6. Experiência no cargo atual que desempenha na sua empresa. *

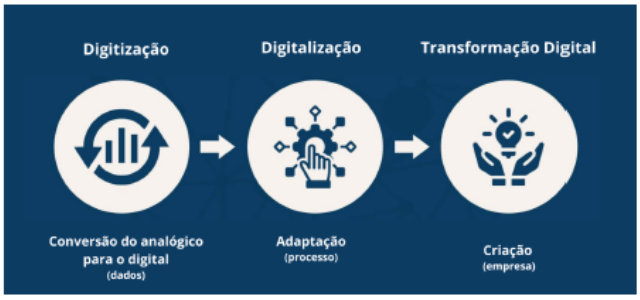
Marcar apenas uma oval.

- ◯ Menos de 1 ano;
- ◯ 1-5 anos;
- ◯ 6-10 anos;
- ◯ 11-15 anos;
- ◯ Mais de 15 anos.

2. Transformação Digital

A digitização é definida como o processo técnico de transformação da informação analógica num formato digital. A digitalização é descrita como o processo socio tecnológico de introdução de aplicações da digitização a nível social e institucional. A digitalização é o efeito da digitização na sociedade.

A transformação digital é composta por 3 fases: digitização, digitalização e transformação digital.



7. 2.1. O conceito de transformação digital é-lhe familiar no seio da empresa para a qual colabora? *

Marcar apenas uma oval.

- Sim;
- Não.

8. 2.2. Considera que a empresa para a qual colabora integra práticas que levam à transformação digital? *

Marcar apenas uma oval.

- Sim;
- Não.

9. 2.3. Numa escala de 1 a 5 classifique as seguintes afirmações quanto à posição da sua empresa em relação às novas tecnologias. *

Considere que 1- Discordo totalmente, 2- Discordo, 3- Não concordo nem discordo, 4- Concordo e 5- Concordo plenamente.

Marcar apenas uma oval por linha.

	1	2	3	4	5
A minha empresa fornece os recursos ou oportunidades para obter as competências necessárias para tirar partido das novas tendências digitais.					
Sou incentivado a inovar com as tecnologias digitais.					
A minha empresa reconhece as tecnologias digitais como uma oportunidade.					
Estou satisfeito com a posição atual da minha empresa em relação às tendências digitais.					

10. 2.4. Numa escala de 1 a 5 classifique as seguintes afirmações acerca do impacto da transformação digital nas empresas. *

Considere que 1- Discordo totalmente, 2- Discordo, 3- Não concordo nem discordo, 4- Concordo e 5- Concordo plenamente.

Marcar apenas uma oval por linha.

	1	2	3	4	5
A transformação digital é um processo que pode estimular as operações do modelo de negócio e criar valor para os clientes.	◯	◯	◯	◯	◯
A transformação digital é um passo inevitável para as organizações sobreviverem no mercado, no entanto requer uma avaliação dos processos, serviços e nível de tecnologia da empresa.	◯	◯	◯	◯	◯
A transformação digital impacta as empresas, a sociedade e as indústrias.	◯	◯	◯	◯	◯

A transformação digital exige a integração das tecnologias digitais nas mais variadas áreas de negócio, como a liderança, as operações, as necessidades dos clientes e a inovação, bem como a forma de como as empresas operam e criam valor para as partes interessadas.					
A transformação digital promove uma cultura inovadora no local de trabalho, aumenta a produtividade e ajuda os líderes a prever e planear os objetivos futuros.					

11. Caso tenha tido dúvidas ou sugestões no preenchimento nesta secção mencione neste campo por favor.

3. Sustentabilidade Ambiental

A sustentabilidade ambiental tem como objetivo primórdio melhorar o bem-estar humano, preservando as fontes de matérias-primas utilizadas para satisfazer as suas necessidades e assegurar que os resíduos são geridos da melhor forma para evitar danos às gerações futuras.

12. 3.1. Considera que existe uma estratégia e/ou política empresarial para reduzir o impacto ambiental da empresa? *

Marcar apenas uma oval.

- ◯ Sim;
- ◯ Não.

13. 3.2. Considera que a sustentabilidade ambiental faz parte da cultura da sua empresa? *

Marcar apenas uma oval.

- ◯ Sim;
- ◯ Não.

14. 3.3. Numa escala de 1 a 5 classifique as seguintes afirmações quanto à posição da sua empresa em relação à sustentabilidade ambiental. *

Considere que 1- Discordo totalmente, 2- Discordo, 3- Não concordo nem discordo, 4- Concordo e 5- Concordo plenamente.

Marcar apenas uma oval por linha.

	1	2	3	4	5
Os colaboradores da minha empresa recebem formação sobre a integração de práticas de sustentabilidade no trabalho quotidiano.	◯	◯	◯	◯	◯
A minha chefia incentiva-me a participar em ações e comportamentos de sustentabilidade em ambiente laboral.	◯	◯	◯	◯	◯
Os funcionários da empresa entendem que os esforços de sustentabilidade se alinham com a estratégia geral.	◯	◯	◯	◯	◯

15. 3.4. Numa escala de 1 a 5 classifique as seguintes afirmações acerca do impacto da transformação digital na sustentabilidade ambiental. *

Considere que 1- Discordo totalmente, 2- Discordo, 3- Não concordo nem discordo, 4- Concordo e 5- Concordo plenamente.

Marcar apenas uma oval por linha.

	1	2	3	4	5
A utilização de tecnologias como Big Data permitem controlar as emissões de CO2 por exemplo, nos veículos ecológicos, preservando as gerações futuras e reduzindo os riscos, custos e danos para o meio ambiente.	◯	◯	◯	◯	◯
Adotando práticas de produção sustentáveis recorrendo, por exemplo, a tecnologias como Big Data e ao Ciclo de Vida do Produto, as empresas podem reduzir os custos operacionais, serem mais lucrativas, melhorar a sua segurança no trabalho e reduzir o seu impacto no ambiente.	◯	◯	◯	◯	◯

O uso de tecnologias digitais como é exemplo a Inteligência Artificial na gestão de resíduos (sejam eles eletrónicos, alimentares, sólidos ou agrícolas), permite diminuir o impacto ambiental que os mesmos têm na sociedade					
A adoção de tecnologias como a Inteligência Artificial, Internet das Coisas e a Análise de Dados, permitem tornar as cidades mais inteligentes e sustentáveis melhorando os recursos das mesmas, proporcionando melhores aos seus cidadãos, reduzindo simultaneamente a sua pegada no ambiente.					

o seu impacto no ambiente.
O uso de tecnologias digitais como é exemplo a Inteligência Artificial na gestão de resíduos (sejam eles eletrónicos, alimentares, sólidos ou agrícolas), permite diminuir o impacto ambiental que os mesmos têm na sociedade.
A adoção de tecnologias como a Inteligência Artificial, Internet das Coisas e a Análise de Dados, permitem tornar as cidades mais inteligentes e sustentáveis melhorando os recursos das mesmas, proporcionando melhores aos seus cidadãos, reduzindo simultaneamente a sua pegada no ambiente.

16. Caso tenha tido dúvidas ou sugestões no preenchimento nesta secção mencione neste campo por favor.

4. Internacionalização

A internacionalização é definida como um processo incremental de expansão das atividades de uma empresas para um cenário internacional, no qual a mesma se envolve e compromete cada vez mais com os negócios internacionais ao introduzir seus produtos em mercados específicos.

17. 4.1. A empresa para a qual desempenha funções tem presença internacional? *

Marcar apenas uma oval.

- ◯ Sim;
- ◯ Não.

18. 4.1.2. Se sim, qual a percentagem de vendas ao estrangeiro no volume de negócios total?

Marcar apenas uma oval.

- ◯ Entre 0 e 10%;
- ◯ Entre 10 e 30%;
- ◯ Entre 30 e 50%;
- ◯ Entre 50 e 70%;
- ◯ Entre 70 e 100%.

19. 4.2. Considera que a transformação digital, aliada à internacionalização é benéfica para uma empresa? *

Marcar apenas uma oval.

- ◯ Sim;
- ◯ Não.

20. 4.3. Numa escala de 1 a 5 classifique as seguintes afirmações acerca do impacto da transformação digital na estratégia de internacionalização das empresas. *

Considere que 1- Discordo totalmente, 2- Discordo, 3- Não concordo nem discordo, 4- Concordo e 5- Concordo plenamente.

Marcar apenas uma oval por linha.

	1	2	3	4	5
Empresas com tecnologias digitais podem oferecer aos clientes novas formas de interação e de criação de valor.	◯	◯	◯	◯	◯
A transformação digital permite às empresas uma melhor gestão de riscos e de custos operacionais nos mercados estrangeiros.	◯	◯	◯	◯	◯
Os avanços tecnológicos possibilitam a desmaterialização dos canais de distribuição e de produção, permitindo às empresas a redução de custos de transação nos mercados estrangeiros.	◯	◯	◯	◯	◯
As tecnologias digitais abrem um novo caminho em termos de inovação, partilha de competências e	◯	◯	◯	◯	◯

de competências e parcerias.					
As tecnologias digitais permitem às empresas uma melhor interação com o cliente e satisfação das suas necessidades.					
As tecnologias digitais permitem às empresas realizar experiências de mercado e partilhá-las globalmente com potenciais consumidores.					
A transformação digital acelera o processo de internacionalização e permite aceder a mercados mais distantes.					

21. Caso tenha tido dúvidas ou sugestões no preenchimento nesta secção mencione neste campo por favor.

Appendix 2: Email sent to the 12 769 enterprises.

Bom dia,

O meu nome é Joana Catarina Rocha Magalhães da Silva e sou aluna do Mestrado em Gestão e Internacionalização de Empresas da Escola Superior de Tecnologia e Gestão do Politécnico do Porto.

Venho pelo presente email solicitar o preenchimento de um questionário que se insere numa investigação no âmbito da minha tese de Mestrado.

O seu contributo é valioso para estudar o conhecimento das empresas portuguesas acerca dos conceitos de Transformação Digital, Sustentabilidade Ambiental e Internacionalização, e do impacto que estes três conceitos têm entre si.

Os dados recolhidos serão tratados confidencialmente garantindo o anonimato.

O tempo estimado de preenchimento é de 6 minutos. O questionário pode ser acedido em: https://forms.gle/hfFQUn7R7sUSYSzU6

Agradeço a atenção dispensada.
Atentamente,
Joana Silva

Appendix 3: Variances and standard deviation

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
2.4 Digital transformation is a process that can boost business model operations and create value for customers.	4,13	,802	296
2.4 Digital transformation is an inevitable step for organizations to survive in the market, however it requires an assessment of the company's processes, services and level of technology.	4,19	,806	296
2.4 Digital transformation impacts businesses, society and industries.	4,23	,794	296
2.4 Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders	4,14	,784	296
2.4 Digital transformation fosters an innovative workplace culture, increases productivity and helps leaders anticipate and plan for future goals.	4,07	,855	296

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
3.4 The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment.	3,58	,906	296
3.4 By adopting sustainable production practices using, for example, technologies such as Big Data and Product Lifecycle, companies can reduce operating costs, be more profitable, improve their safety at work and reduce their impact on the environment	3,66	,904	296
3.4 The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society.	3,70	,946	296
3.4 The adoption of technologies such as Artificial Intelligence, Internet of Things and Data Analytics, allow cities to become smarter and more sustainable by improving their resources, providing access to better services to their citizens, while reducin	3,77	,925	296

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
4.3 Companies with digital technologies can offer customers new ways of interacting and creating value.	4,21	,803	296
4.3 Digital transformation allows companies to better manage risks and operational costs in foreign markets.	4,14	,805	296
4.3 Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets.	4,06	,810	296
4.3 Digital technologies open a new path in terms of innovation, skills sharing and partnerships.	4,22	,781	296
4.3 Digital technologies allow companies to better interact with customers and meet their needs.	4,25	,779	296
4.3 Digital technologies allow companies to conduct market experiments and share them globally with potential consumers.	4,20	,761	296
4.3 Digital transformation accelerates the internationalization process and allows access to more distant markets.	4,22	,818	296

Appendix 4: Significance levels

Correlation Matrix

		2.4 Digital transformation is a process that can boost business model operations and create value for customers.	2.4 Digital transformation is an inevitable step for organizations to survive in the market, however it requires an assessment of the company's processes, services and level of technology.	2.4 Digital transformation impacts businesses, society and industries.	2.4 Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders	2.4 Digital transformation fosters an innovative workplace culture, increases productivity and helps leaders anticipate and plan for future goals.
Correlation	2.4 Digital transformation is a process that can boost business model operations and create value for customers.	1,000	,685	,645	,715	,728
	2.4 Digital transformation is an inevitable step for organizations to survive in the market, however it requires an assessment of the company's processes, services and level of technology.	,685	1,000	,712	,764	,670
	2.4 Digital transformation impacts businesses, society and industries.	,645	,712	1,000	,750	,636
	2.4 Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders	,715	,764	,750	1,000	,729
	2.4 Digital transformation fosters an innovative workplace culture, increases productivity and helps leaders anticipate and plan for future goals.	,728	,670	,636	,729	1,000
Sig. (1-tailed)	2.4 Digital transformation is a process that can boost business model operations and create value for customers.		<,001	<,001	<,001	<,001
	2.4 Digital transformation is an inevitable step for organizations to survive in the market, however it requires an assessment of the company's processes, services and level of technology.	,000		,000	,000	,000
	2.4 Digital transformation impacts businesses, society and industries.	,000	,000		,000	,000
	2.4 Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders	,000	,000	,000		,000
	2.4 Digital transformation fosters an innovative workplace culture, increases productivity and helps leaders anticipate and plan for future goals.	,000	,000	,000	,000	

Correlation Matrix

		3.4 The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment.	3.4 By adopting sustainable production practices using, for example, technologies such as Big Data and Product Lifecycle, companies can reduce operating costs, be more profitable, improve their safety at work and reduce their impact on the environment	3.4 The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society.	3.4 The adoption of technologies such as Artificial Intelligence, Internet of Things and Data Analytics, allow cities to become smarter and more sustainable by improving their resources, providing access to better services to their citizens, while reducin
Correlation	3.4 The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment.	1,000	,752	,637	,606
	3.4 By adopting sustainable production practices using, for example, technologies such as Big Data and Product Lifecycle, companies can reduce operating costs, be more profitable, improve their safety at work and reduce their impact on the environment	,752	1,000	,663	,684
	3.4 The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society.	,637	,663	1,000	,850
	3.4 The adoption of technologies such as Artificial Intelligence, Internet of Things and Data Analytics, allow cities to become smarter and more sustainable by improving their resources, providing access to better services to their citizens, while reducin	,606	,684	,850	1,000
Sig. (1-tailed)	3.4 The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment.		<,001	<,001	<,001
	3.4 By adopting sustainable production practices using, for example, technologies such as Big Data and Product Lifecycle, companies can reduce operating costs, be more profitable, improve their safety at work and reduce their impact on the environment	,000		,000	,000
	3.4 The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society.	,000	,000		,000
	3.4 The adoption of technologies such as Artificial Intelligence, Internet of Things and Data Analytics, allow cities to become smarter and more sustainable by improving their resources, providing access to better services to their citizens, while reducin	,000	,000	,000	

Correlation Matrix

		4.3 Companies with digital technologies can offer customers new ways of interacting and creating value.	4.3 Digital transformation allows companies to better manage risks and operational costs in foreign markets.	4.3 Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets.	4.3 Digital technologies open a new path in terms of innovation, skills sharing and partnerships.	4.3 Digital technologies allow companies to better interact with customers and meet their needs.	4.3 Digital technologies allow companies to conduct market experiments and share them globally with potential consumers.	4.3 Digital transformation accelerates the internationalization process and allows access to more distant markets.
Correlation	4.3 Companies with digital technologies can offer customers new ways of interacting and creating value.	1,000	,825	,682	,776	,796	,760	,755
	4.3 Digital transformation allows companies to better manage risks and operational costs in foreign markets.	,825	1,000	,755	,760	,772	,764	,725
	4.3 Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets.	,682	,755	1,000	,754	,732	,722	,720
	4.3 Digital technologies open a new path in terms of innovation, skills sharing and partnerships.	,776	,760	,754	1,000	,875	,813	,821
	4.3 Digital technologies allow companies to better interact with customers and meet their needs.	,796	,772	,732	,875	1,000	,816	,781
	4.3 Digital technologies allow companies to conduct market experiments and share them globally with potential consumers.	,760	,764	,722	,813	,816	1,000	,796
	4.3 Digital transformation accelerates the internationalization process and allows access to more distant markets.	,755	,725	,720	,821	,781	,796	1,000
Sig. (1-tailed)	4.3 Companies with digital technologies can offer customers new ways of interacting and creating value.		<,001	<,001	<,001	<,001	<,001	<,001
	4.3 Digital transformation allows companies to better manage risks and operational costs in foreign markets.	,000		,000	,000	,000	,000	,000
	4.3 Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets.	,000	,000		,000	,000	,000	,000
	4.3 Digital technologies open a new path in terms of innovation, skills sharing and partnerships.	,000	,000	,000		,000	,000	,000
	4.3 Digital technologies allow companies to better interact with customers and meet their needs.	,000	,000	,000	,000		,000	,000
	4.3 Digital technologies allow companies to conduct market experiments and share them globally with potential consumers.	,000	,000	,000	,000	,000		,000
	4.3 Digital transformation accelerates the internationalization process and allows access to more distant markets.	,000	,000	,000	,000	,000	,000	

Appendix 3: Anti-Image Matrix

Anti-image Matrices

		2.4 Digital transformation is a process that can boost business model operations and create value for customers.	2.4 Digital transformation is an inevitable step for organizations to survive in the market, however it requires an assessment of the company's processes, services and level of technology.	2.4 Digital transformation impacts businesses, society and industries.	2.4 Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders	2.4 Digital transformation fosters an innovative workplace culture, increases productivity and helps leaders anticipate and plan for future goals.
Anti-image Covariance	2.4 Digital transformation is a process that can boost business model operations and create value for customers.	,373	-,068	-,042	-,058	-,139
	2.4 Digital transformation is an inevitable step for organizations to survive in the market, however it requires an assessment of the company's processes, services and level of technology.	-,068	,344	-,095	-,100	-,042
	2.4 Digital transformation impacts businesses, society and industries.	-,042	-,095	,380	-,112	-,027
	2.4 Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders	-,058	-,100	-,112	,276	-,087
	2.4 Digital transformation fosters an innovative workplace culture, increases productivity and helps leaders anticipate and plan for future goals.	-,139	-,042	-,027	-,087	,371
Anti-image Correlation	2.4 Digital transformation is a process that can boost business model operations and create value for customers.	,898[a]	-,189	-,112	-,180	-,373
	2.4 Digital transformation is an inevitable step for organizations to survive in the market, however it requires an assessment of the company's processes, services and level of technology.	-,189	,899[a]	-,263	-,325	-,118
	2.4 Digital transformation impacts businesses, society and industries.	-,112	-,263	,902[a]	-,345	-,072
	2.4 Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders	-,180	-,325	-,345	,869[a]	-,272
	2.4 Digital transformation fosters an innovative workplace culture, increases productivity and helps leaders anticipate and plan for future goals.	-,373	-,118	-,072	-,272	,892[a]

a. Measures of Sampling Adequacy(MSA)

Anti-image Matrices

		3.4 The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment.	3.4 By adopting sustainable production practices using, for example, technologies such as Big Data and Product Lifecycle, companies can reduce operating costs, be more profitable, improve their safety at work and reduce their impact on the environment	3.4 The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society.	3.4 The adoption of technologies such as Artificial Intelligence, Internet of Things and Data Analytics, allow cities to become smarter and more sustainable by improving their resources, providing access to better services to their citizens, while reducin
Anti-image Covariance	3.4 The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment.	,400	-,208	-,067	,006
	3.4 By adopting sustainable production practices using, for example, technologies such as Big Data and Product Lifecycle, companies can reduce operating costs, be more profitable, improve their safety at work and reduce their impact on the environment	-,208	,351	-,017	-,078
	3.4 The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society.	-,067	-,017	,253	-,180
	3.4 The adoption of technologies such as Artificial Intelligence, Internet of Things and Data Analytics, allow cities to become smarter and more sustainable by improving their resources, providing access to better services to their citizens, while reducin	,006	-,078	-,180	,251
Anti-image Correlation	3.4 The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment.	,791[a]	-,557	-,209	,019
	3.4 By adopting sustainable production practices using, for example, technologies such as Big Data and Product Lifecycle, companies can reduce operating costs, be more profitable, improve their safety at work and reduce their impact on the environment	-,557	,794[a]	-,057	-,263
	3.4 The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society.	-,209	-,057	,738[a]	-,714
	3.4 The adoption of technologies such as Artificial Intelligence, Internet of Things and Data Analytics, allow cities to become smarter and more sustainable by improving their resources, providing access to better services to their citizens, while reducin	,019	-,263	-,714	,729[a]

a. Measures of Sampling Adequacy(MSA)

Anti-image Matrices

		4.3 Companies with digital technologies can offer customers new ways of interacting and creating value.	4.3 Digital transformation allows companies to better manage risks and operational costs in foreign markets.	4.3 Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets.	4.3 Digital technologies open a new path in terms of innovation, skills sharing and partnerships.	4.3 Digital technologies allow companies to better interact with customers and meet their needs.	4.3 Digital technologies allow companies to conduct market experiments and share them globally with potential consumers.	4.3 Digital transformation accelerates the internationalization process and allows access to more distant markets.
Anti-image Covariance	4.3 Companies with digital technologies can offer customers new ways of interacting and creating value.	,239	-,110	,022	-,013	-,042	-,016	-,043
	4.3 Digital transformation allows companies to better manage risks and operational costs in foreign markets.	-,110	,236	-,091	-,003	-,015	-,036	,004
	4.3 Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets.	,022	-,091	,336	-,041	-,016	-,024	-,043
	4.3 Digital technologies open a new path in terms of innovation, skills sharing and partnerships.	-,013	-,003	-,041	,171	-,083	-,027	-,061
	4.3 Digital technologies allow companies to better interact with customers and meet their needs.	-,042	-,015	-,016	-,083	,182	-,047	-,004
	4.3 Digital technologies allow companies to conduct market experiments and share them globally with potential consumers.	-,016	-,036	-,024	-,027	-,047	,241	-,065
	4.3 Digital transformation accelerates the internationalization process and allows access to more distant markets.	-,043	,004	-,043	-,061	-,004	-,065	,257
Anti-image Correlation	4.3 Companies with digital technologies can offer customers new ways of interacting and creating value.	,922[a]	-,461	,078	-,066	-,201	-,068	-,174
	4.3 Digital transformation allows companies to better manage risks and operational costs in foreign markets.	-,461	,911[a]	-,323	-,017	-,072	-,149	,014
	4.3 Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets.	,078	-,323	,949[a]	-,169	-,064	-,085	-,146
	4.3 Digital technologies open a new path in terms of innovation, skills sharing and partnerships.	-,066	-,017	-,169	,915[a]	-,470	-,132	-,290
	4.3 Digital technologies allow companies to better interact with customers and meet their needs.	-,201	-,072	-,064	-,470	,922[a]	-,224	-,019
	4.3 Digital technologies allow companies to conduct market experiments and share them globally with potential consumers.	-,068	-,149	-,085	-,132	-,224	,955[a]	-,261
	4.3 Digital transformation accelerates the internationalization process and allows access to more distant markets.	-,174	,014	-,146	-,290	-,019	-,261	,945[a]

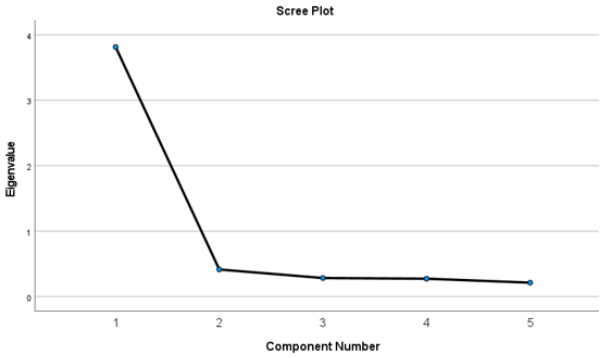
a. Measures of Sampling Adequacy(MSA)

Appendix 6: Total Variance Explained and Scree plot

Total Variance Explained

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	3,815	76,300	76,300

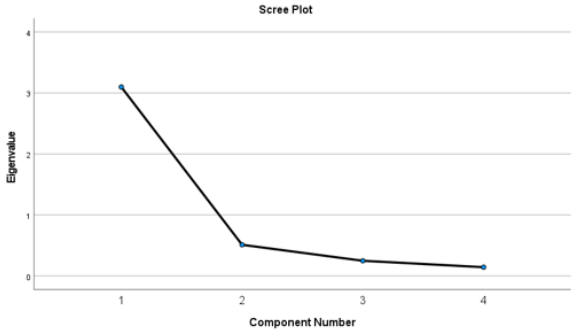
Extraction Method: Principal Component Analysis.



Total Variance Explained

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	3,098	77,443	77,443

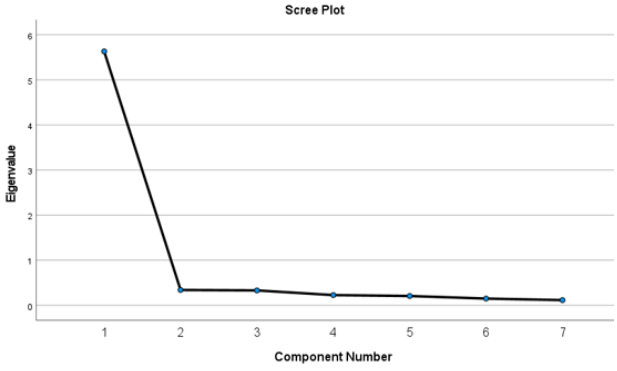
Extraction Method: Principal Component Analysis.



Total Variance Explained

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	5,632	80,462	80,462

Extraction Method: Principal Component Analysis.



Appendix 7: Communalities

Communalities

	Extraction
2.4 Digital transformation is a process that can boost business model operations and create value for customers.	,745
2.4 Digital transformation is an inevitable step for organizations to survive in the market, however it requires an assessment of the company's processes, services and level of technology.	,771
2.4 Digital transformation impacts businesses, society and industries.	,733
2.4 Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders	,825
2.4 Digital transformation fosters an innovative workplace culture, increases productivity and helps leaders anticipate and plan for future goals.	,741

Extraction Method: Principal Component Analysis.

Communalities

	Extraction
3.4 The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment.	,717
3.4 By adopting sustainable production practices using, for example, technologies such as Big Data and Product Lifecycle, companies can reduce operating costs, be more profitable, improve their safety at work and reduce their impact on the environment	,773
3.4 The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society.	,806
3.4 The adoption of technologies such as Artificial Intelligence, Internet of Things and Data Analytics, allow cities to become smarter and more sustainable by improving their resources, providing access to better services to their citizens, while reducin	,801

Extraction Method: Principal Component Analysis.

Communalities

	Extraction
4.3 Companies with digital technologies can offer customers new ways of interacting and creating value.	,795
4.3 Digital transformation allows companies to better manage risks and operational costs in foreign markets.	,795
4.3 Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets.	,726
4.3 Digital technologies open a new path in terms of innovation, skills sharing and partnerships.	,856
4.3 Digital technologies allow companies to better interact with customers and meet their needs.	,848
4.3 Digital technologies allow companies to conduct market experiments and share them globally with potential consumers.	,817
4.3 Digital transformation accelerates the internationalization process and allows access to more distant markets.	,795

Extraction Method: Principal Component Analysis.

Appendix 8: Rotated Component Matrix

Component Score Coefficient Matrix

	Component 1
2.4 Digital transformation is a process that can boost business model operations and create value for customers.	,226
2.4 Digital transformation is an inevitable step for organizations to survive in the market, however it requires an assessment of the company's processes, services and level of technology.	,230
2.4 Digital transformation impacts businesses, society and industries.	,224
2.4 Digital transformation requires integrating digital technologies into a wide range of business areas, such as leadership, operations, customer needs and innovation, as well as transforming the way businesses operate and create value for stakeholders	,238
2.4 Digital transformation fosters an innovative workplace culture, increases productivity and helps leaders anticipate and plan for future goals.	,226

Extraction Method: Principal Component Analysis.
Component Scores.

Component Score Coefficient Matrix

	Component 1
3.4 The use of technologies such as Big Data makes it possible to control CO2 emissions, for example in green vehicles, preserving future generations and reducing risks, costs and damage to the environment.	,273
3.4 By adopting sustainable production practices using, for example, technologies such as Big Data and Product Lifecycle, companies can reduce operating costs, be more profitable, improve their safety at work and reduce their impact on the environment	,284
3.4 The use of digital technologies such as Artificial Intelligence in waste management (whether electronic, food, solid or agricultural), allows to reduce the environmental impact that they have on society.	,290
3.4 The adoption of technologies such as Artificial Intelligence, Internet of Things and Data Analytics, allow cities to become smarter and more sustainable by improving their resources, providing access to better services to their citizens, while reducin	,289

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Component Matrix[a]

	Component 1
4.3 Digital technologies open a new path in terms of innovation, skills sharing and partnerships.	,925
4.3 Digital technologies allow companies to better interact with customers and meet their needs.	,921
4.3 Digital technologies allow companies to conduct market experiments and share them globally with potential consumers.	,904
4.3 Digital transformation accelerates the internationalization process and allows access to more distant markets.	,892
4.3 Digital transformation allows companies to better manage risks and operational costs in foreign markets.	,892
4.3 Companies with digital technologies can offer customers new ways of interacting and creating value.	,891
4.3 Technological advances enable the dematerialization of distribution and production channels, allowing companies to reduce transaction costs in foreign markets.	,852

Extraction Method: Principal Component Analysis.
a. 1 components extracted.