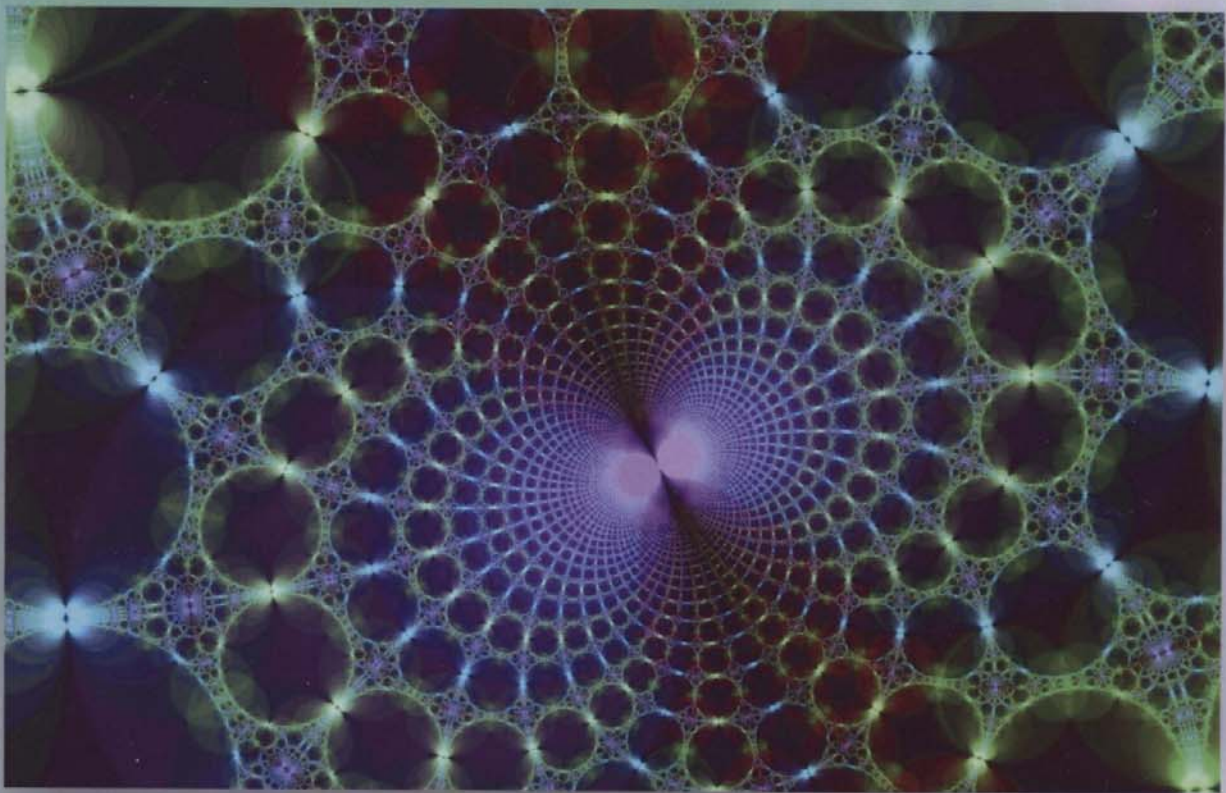


DYNAMICAL SYSTEMS

— Theory —



EDITORS

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A multidimensional scaling perspective of Rostow's forecasts with the track-record (1960s-2011) of "pioneers" and "latecomers"

José António Tenreiro Machado, Maria Eugénia Mata

Abstract: The modeling of world economy evolution and the analysis of its dynamics poses problems of defining the proper concepts and mathematical tools for an assertive study. This paper applies multidimensional scaling (MDS) methodology to the evolution of GDP per capita, international trade openness, life expectancy, and education tertiary enrollment, as indicators of human development for 19 countries analyzed in Walter Rostow's Stages of Economic Growth. Results prove to be less optimistic than Neoclassical convergence projections based on the use of resources and decreasing marginal rates of return, but cannot reject Fogel, 2007, regarding a global geopolitical turnover by 2040.

1. Introduction

The number of empirical studies on economic growth increased toward the end of the twentieth century, and the interest in this issue has become even more acute since the turn of the new millennium (see Sala-i-Martin, 1994, for a literature survey).

Among economic historians, industrialization, modernization, and globalization stimulated spirited discussions on the economic growth conditions that could be gathered in nineteenth-century pioneering countries, such as the UK, the small Northern-European partners, France, the USA, and many other countries from the Old World.

The dominant views have stressed how important has been the convergence among them and twentieth-century followers, particularly when the restoration of peace created the conditions for economic normality. Independent of the departure levels of wealth, convergence means that poor economies tended to grow faster than rich ones in per capita terms. The Allied Nations victory led to the creation of the United, and considerable analytical effort was framed in the context of the global post-war perspective. Reconstruction meant recovery, and the political ideals of Churchill and Roosevelt included not only sustainable peace but also sustainable economic growth and prosperity for all. The Marshall Plan expressed the

hope that positive effects of technological imitation and innovation would support economic growth, an approach that Solow (1956) would adopt for his growth model based on population growth rate, labor force, savings, capital per worker, and decreasing marginal capital returns. Economic growth was meant to provide job opportunities and modernization in reaping the respective spillovers.

These hopes led the way to the January 1961 United Nations' declaration that the 1960s would be "a decade for growth and development", within a New International Economic Order (NIEO). Hopes about the effects of foreign trade openness also brought the desire to develop global partnerships, and to include countries that had been subject to European colonization. In fact, decolonization was a main goal for large regions of the world following the 1955 Bandung Conference. It was hoped that independence would provide the conditions for local economic growth strategies and policies, paving the way to the global spread of industrialization and modernization. These hopes were partially realized, and the 1964 United Nations Conference on Trade and Development (UNCTAD) again declared the 1970s as a new pivotal "decade for growth and development" (Aoyama, 2012).

Gerschenkron's 1962 book *Economic backwardness in historical perspective...* may be interpreted in this historical context, in postulating that the more backward an economy was at the outset of development, the greater reliance it would show in performing for growth. Walter Rostow's 1960 book, *The Stages of Economic Growth ...*, optimistically assigned a chronology to each growth-pioneering nation of the past, in terms of each one of the five stages that should lead any nation to mass-consumption prosperity: beginning from a traditional-economy stage, the gathering of economic growth pre-conditions, followed by a take-off, and industrial maturation should take nations to a final fifth stage of mass consumption.

Among economic historians, iconic books on poverty and prosperity were (and still are) amazing sources of reflection. To mention only three landmarks, Van der Wee's 1987 book *Prosperity and Upheaval* is an optimistic view on the spread and convergence of economic growth; Landes' 1999 book *The causes of Poverty and Prosperity of Nations (...)* is a challenging report of variables that may command growth and prosperity; and Acemoglu and Robinson's *Why Nations Fail, The Origins of Power, Prosperity and Poverty* is a set of additional variables to the factors that have historically represented hurdles to economic growth and modernization of many countries in the world, particularly those in Africa (these are only some of many others that might be quoted). Krugman (1999) goes with even greater enthusiasm because of deep and ongoing crises in many developed countries. If this is an interesting issue for historians, it also represents a pressing social mission for politicians and economists, as economic growth supports prosperity and welfare.

Five decades separate our world from the 1960s. Five decades is exactly the time duration for the maturity phase in Rostow's theory. What can be said today about the accuracy of those optimistic forecasts and the implementation of growth, economic performance, human development, and welfare? The achievement of growth throughout the different Rostowian phases is meant to produce new and happier conditions of life, including increasing levels of GDP per capita, international solidarity through international division of labor that is reflected in foreign trade openness, and increasing population life expectancy, while youth education may be a driver of inequality as it endogenously provides the human capital that is required in more and more sophisticated technological systems (for life expectancy see Acemoglu, 2007). As for education, a stock variable such as schooling years for persons above 25 (or 15) may be most representative, as it has increased considerably and is very meaningful for jobs, but flow variables on education are longer and more complete. GDP per capita, the weight of commodity and services trade in GDP, life expectancy at birth, and tertiary enrollment are the exact variables that were selected in this paper to check and answer the above questions (Although the World Bank series has a time gap, the tertiary education level is the variable that most relates human capital with technological achievement, throughout the five decades analyzed). Moreover, the development of the concept of a human development index, based on the selection of human development indicators, also recommends them (Prados, 2012).

This paper seeks to assess similarities and dissimilarities among the countries that pioneered industrialization, according to Rostow, decade after decade, from 1960 to the present, the moment when the accomplishment of maturation means the achievement of mass consumption in all those economies. The sample comprises countries that Rostow identifies as having started the take-off stage (only Taiwan and South Korea are not included, because of missing World Bank statistical data). The sample was collected from the World Bank Statistics, and the methodology adopted is based on multidimensional scaling (MDS) to visually check the proximity and similarities among countries throughout each of the five decades. The results obtained are quite interesting in that they provide a plausible manner in which to depict the evolution and economic similarity of the sampled countries.

2. Literature review

Explanations for convergence were based on the analytical tools using neoclassical growth models, because the speed of convergence accords with the existence of diminishing returns to capital. So, "*other things being equal*, countries with low amounts of capital are predicted to grow faster. This negative relation between the growth rate and the initial level of income is what we call the *convergence hypothesis*" (Sala-y-Martin, 1994). However, after Romer

(1986), endogenous-growth models were also developed, based on the conclusion that cross-sectional evidence did not exist for convergence among a sample of countries covering the 1950-70 period. According to these models the poor countries were not growing faster than rich ones, when purchasing power parity values were used for a sample of 100 countries (Summers and Heston, 1988). Dowrick and Nguyen (1989) report convergence for OECD countries' productivity in the 1950-85 period, but Barro (1991) demonstrates that in a sample of the same size, many other variables were much more important for growth and prosperity than the initial revenue level. Levine and Renelt (1992) demonstrated that a small number of variables were significant, in presenting an econometric cross-sectional analysis to explain growth. One variable was openness to foreign trade, which led to the definition of a new concept for convergence (economic policy was also a very relevant explanation). The claim became that *conditional convergence* occurs and it expresses the inverse relationship between growth and the distance to steady state (Mankiw, Romer, Weil, 1992). This conclusion was confirmed in exercises addressing contiguous states in the USA, particularly because of sharing the same institutional background in belonging to a same country, and because of free capital flows (as regional capital loans can occur easily) (Barro, Sala-y-Martin, 1992).

In an optimistic way, Sala-y-Martin (1994) concludes that a 2% rate of convergence was very common in databases, and that 35 years were enough to cancel half of the distance of a country to its steady-state (and 70 years to cancel the whole distance). A similar optimistic view on convergence, for both open and closed economies, comes from Barro, Mankiw, and Sala-y-Martin (1995) in allowing (total or partial) capital mobility, because open economies converge only slightly more quickly than closed economies, a conclusion corroborated by the open USA and the more closed OECD countries. Running more than two million regressions, Sala-y-Martin (1997) checked many more variables including regional, political, sociological, and global shock problems. Sala-y-Martin (2005) confirms that poverty rates in 2000 "were between one-third and one-half of what they were in 1970. There were 500 million fewer poor in 2000 than in 1970" (see also Sen, 2000). In a different perspective, economic historians developed human development indexes in a long-run perspective. Before the new millennium, conclusions were very optimistic about the continuous increase of human development indexes throughout the globe, and were also convergence supportive: "HDI in most of today's less-developed countries exceeds that of Western Europe in 1870 and (...) the gaps in HDI between Western Europe and each of Africa, China and India were smaller in 1999 than in 1950. Both the outcomes have been heavily influenced by widespread gains in life expectancy" (Crafts, 2002).

For the new millennium, however, opinions are more cautious and favor a stagnation view, particularly for the second half of the decade. Using a different estimation methodology,

Prados (2012) concludes that there was “catching-up to the OECD in the Rest in terms of human development, life expectancy and education, but not in GDP per capita”. The successive financial crises (2002 in Argentina, 2004 in Japan, 2007 in the USA, 2009 in Ireland, 2010 in Greece, 2011 in Portugal, and 2012 in Spain and Italy) and the fears of the European project failure have given rise to a large amount of literature on international finance and global forecasts. Krugman (1999) anticipated the Depression problems, and Eichengreen (2002 and 2006) focused on the financial crises and global imbalances, while interest in the 1929-1933 Great Depression multiplied the studies on lessons from the past (Bordo, 2010) and the site O’Rourke/Eichengreen “A Tale on two Depressions”. However, Fogel (2007) presents the most pessimistic view in foreseeing a tremendous relative decline for the GDP shares of the USA and the EU15 in the global GDP: for 2040 he estimates 14 percent and 5 percent respectively (these were 22 and 21 percent in 2000, respectively). On the contrary, in 2040 there will be a new increasing weight of Asian partners: “The Chinese market in 2040 by itself will probably be larger than the combined markets of the U.S., the EU15, India, and Japan”. As a consequence, Fogel even foresees the risk of terrible political adjustments around the planet, because the Asian partners are not trustful in terms of promoting democracy, and “Liberal democracy is thriving in India”.

None of the available contributions brings a detailed perspective on countries, in considering their similarities and dissimilarities throughout the process of economic growth and performance, a view that may be obtained by using multi-scaling dynamic (MDS) methodologies to calculate proximity (Machado, 2011, Machado, 2012). In estimating distance as an indicator of proximities through the most used variables on prosperity and human development, its strong capacity as a summarizing assessment makes it a superb analytical instrument for describing similarity levels and close historical experiences when applied to empirical database approaches. Multi-dimensional graphs can “open a new era in the economic analysis from a microeconomic and macroeconomic view, particularly as it is now possible to observe dynamic and complex economic phenomena through time and space in the same graphical space” (Estrada, 2012).

3. Data and methodology

The database for 19 countries includes GDP per capita, openness (given by the percentage of exports in GDP), life expectancy, and education tertiary enrollment for a five decades time-span. Data were collected from the *World Bank national development indicators* which cover exactly the period coming from 1960 to the present (2012) (source <http://data.worldbank.org/data-catalog/world-development-indicators> from 1970 onward for education).

- GDP per capita, comes from NY.GNP.PCAP.KD. It is the GNI per capita (constant

2000 US\$). GNI per capita is gross national income divided by midyear population. GNI (formerly GNP) is the sum of value added by all resident producers plus any product taxes (less subsidies) not included in the valuation of output plus net receipts of primary income (compensation of employees and property income) from abroad. Data are in constant 2000 U.S. dollars.

- Annual exports of goods and services (% of GDP) comes from NE.EXP.GNFS.ZS. Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude compensation of employees and investment income (formerly called factor services) and transfer payments. It is a weighted average. Data are expressed in percentage of GDP.

Life expectancy comes from SP.DYN.LE00.IN. Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.

School enrollment, tertiary (% gross) comes from SE.TER.ENRR. Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally requires, as a minimum condition of admission, the successful completion of education at the secondary level. Data are expressed in percentage.

The time series for tertiary enrollment is the least complete, but all education time series present missing observations. (Barro & Lee, 2012) database for 1950-2010 is an excellent source for education, but the information is only given for every five years. The UNESCO education database has yearly information, but only covers 1970-1997, with missing points.

MDS is a computational, statistical, and visualization technique that produces a representation of similarity, or, alternatively, of distances, between objects by means of relatedness (Cox, 2001). The term similarity denotes the degree of “likeness” between two objects in some mathematical sense, while distance indicates the opposite (Kruskal, 1978).

The production of an MDS representation of n objects requires the calculation of an $n \times n$ symmetrical matrix \mathbf{R} measuring the cross correlation between all objects. The objects are points in the MDS map and represent vectors of data describing economic variables. When the correlation between two objects is one/zero, the distance between them is zero/infinite, and the corresponding MDS points are superimposed/very far apart. Inversely, if two points are located closely/far apart in the MDS plot, then there is a large/small correlation between the corresponding data vectors (Borg, 2005).

Vector normalization was used in order to consider the absolute interval of the adopted variables.

MDS executes a numerical optimization procedure to estimate the coordinates of the points in an m -dimensional map, based on matrix \mathbf{R} storing the correlation (to be defined in some mathematical sense) between all pairs of objects (Cha, 2008). Often it is considered $m = 2$ or $m = 3$, simply because it leads to a direct graphical visualization of the MDS map. Here the objects are country economies characterized by means of a given set of variables evaluated during a given time period.

The symmetric matrix $\mathbf{R} = [r_{ij}]$ main diagonal is composed of ones/zeros for correlation/distances, while the rest of the matrix elements must obey the restriction $0 \leq r_{ij} \leq 1$, $i, j = 1, \dots, n$. Since MDS works with relative measurements, the resulting maps are not sensitive to translations or rotations and the axes have only the meaning and units (if any) of the measuring index. MDS rearranges objects in order to produce a map that best approximates the observed similarities. A measure for evaluating the accuracy of the MDS solution is the raw stress. The smaller the stress value, the better is the fit. Plotting the stress versus the number of dimensions m of the MDS map produces a monotonic decreasing chart. The user chooses the “best” dimension as a compromise between stress reduction and number of dimensions for the map representation.

MDFS software is often referred to in the literature as a statistical tool, but its main characteristic is that it provides a means of *visualizing* items without requiring additional constraints or by defining *a priori* restrictions. The MDS map reflects the properties of the similarity measures and distinct indices produce different maps. Therefore, MDS charts lead to a direct visualization of results that can also be obtained by the combination of the same analytical techniques with the expense of a more laborious comparison.

The classic MDS does not explicitly include a description of time/space evolution. Capturing time/space dynamics may be embedded indirectly into the correlation measure as long the comparison index between variables has some built-in feature. For example, a histogram-based correlation discharges time dependent phenomena. For highlighting time dynamics explicitly, the division of the total time period of analysis into several time periods of width h to be treated by MDS as independent objects was proposed. Consequently, for a total time period T , this method produces $p = T/h$ samples and the number of MDS points increases proportionally. In this line of thought, the time samples to be adopted are a compromise between capturing fast dynamics (possible only with small values of h), and producing a limited number of MDS points (which requires large values of h). Available data allows us to consider time series along a period $T = 50$ years, namely from 1960 up to 2009. In the sequel two cases are considered, namely a comparison based on the whole period of

time, that is $h = 50$ ($p = 1$) and $h = 10$ ($p = 5$). Furthermore, a set of $n_c = 19$ countries is tackled, namely {ARG, AUS, BRA, CAN, CHN, FRA, DEU, IND, IRN, ITA, JPN, MEX, PRT, RUS, SWE, THA, TUR, GBR, USA} \equiv {Argentina, Austria, Brazil, Canada, China, France, Germany, India, Iran, Italy, Japan, Mexico, Portugal, Russian Federation, Sweden, Thailand, Turkey, UK, US}, from the universe of Rostow's model members. We obtain $n = n_c \times p$ objects to be analyzed in the MDS, of h years length each. Therefore, the two cases consist of $p = 5, h = 10, n = 95$ and $p = 1, h = 50, n = 19$, to be denoted in the sequel as A and B respectively. In the chart, points labeled as "AUS1" or "USA5" mean Austria during the first decade period (1960-1969) and United States during the last decade period (2000-2009), respectively. As mentioned above $l = 4$ economic variables namely {GDP per capita, openness, life expectancy, education tertiary enrollment} are adopted for characterizing each country economy, having identical weights.

It was decided to proceed with a "normalization" of the economic variables prior to any calculation, in order to avoid any biasing of the similarity measures. Denoting by \check{x}_i the value of the i -th initial economic variable, the normalized variable x_i was calculated by subtracting the average and dividing by the rms. Therefore, we adopted a transformation usual in signal processing and in the sequel the variable $x_i = \frac{\check{x}_i - \bar{x}_i}{\tilde{x}_i}$, such that $\bar{x}_i = \frac{1}{T} \int_0^T \check{x}_i dt$, $\tilde{x}_i = \sqrt{\frac{1}{T} \int_0^T (\check{x}_i - \bar{x}_i)^2 dt}$.

The data set of four economic variables had some handling difficulties because in several cases values were missing. In general, all countries had some years without data values that had to be estimated by means of linear interpolation between adjacent years. In particular the Russian Federation, for all variables, and Germany for the education tertiary enrollment had many missing values. Also, for the education tertiary enrollment, all values for the period 1960-69 were missing. In these cases the values were estimated by mean of trendlines. For avoiding anomalous values an iterative procedure was adopted: (i) For each variable, the time evolution for the whole set of countries was plotted, (ii) for each country a non-linear individual trendline was calculated, (iii) the values emerging from a given type of trendline were compared with the values of the remaining countries (in order to test the relative positions) and with the succeeding values (in order to test the consistency with the real values), and (iv) the trendline was accepted/changed by another one if the visual comparison did/did not succeed. While this manual labor was somewhat tedious, it prevented from adopting misleading values. The practical implementation proved to be faster than expected because the variables have a smooth evolution and tend to evolve similarly. Therefore, different trendlines produced values relatively close and, therefore, the estimation error is not significant.

For constructing matrix $\mathbf{R} = [r_{ij}]$ two alternative indices are adopted, namely the cosine

correlation and the distance, defined as:

$$r_{ij} = \frac{\sum_{t=1}^h \sum_{k=1}^l x_i(k, t) x_j(k, t)}{\sqrt{\sum_{t=1}^h \sum_{k=1}^l x_i^2(k, t) \cdot \sum_{t=1}^h \sum_{k=1}^l x_j^2(k, t)}}, \quad i, j = 1, \dots, n, \quad (1)$$

$$r_{ij} = \sum_{t=1}^h \sum_{k=1}^l [x_i(k, t) - x_j(k, t)]^2, \quad i, j = 1, \dots, n, \quad (2)$$

where x_i and x_j are economic variables for the i -th and j -th objects, t and k denote two dummy indices representing time and type of economic variable, h consists of the sampling period, and n denotes the total number of objects. Equation (1) is the normalized inner product and is often called the cosine coefficient because it measures the angle between two vectors, denoting an angular metric (Deza and Deza, 2006; Cha, 2008). Equation (2) is inspired in the Euclidean distance over the time period.

The decennial approach seems to be appropriate for capturing a picture of the relative similarities among countries. Shorter periods would allow for more time detail, but the number of points in the plots would increase, making them more difficult to read. The decennial approach also may help in comprising any Juglar business-cycle behavior that may influence the countries' achievements. Furthermore, expressions (1) and (2) have an embedded implicit description of the time evolution, which would not be possible with other measures such as, for example, histograms. Therefore, cases A and B differ simply because they reflect time dynamics more or less explicitly.

4. The MDS results

We can find procedures for calculating MDS maps in packages such as Matlab and R. In the present paper the authors decided to adopt GGobi, an open source program not only because it produces MDS charts, but also because it has additional tools that enable excellent visualization, such as automatic and manual rotation, zoom, labeling, coloring, and shifting.

A different symbol signals the results for each of the decades (a shaded circle for the 1960s, a circle for the 1970s, a shaded square for the 1980s, a square for the 1990s, and an "x" for the new-millennium 2000s). Also, each point is labeled with three letters for the country followed by a number for the decade. The stress plot revealed that $m = 3$ establishes a good compromise between accuracy and visualization simplicity. Since the figures are merely 2-dimensional projections of a 3-dimensional map, the reader can be deceived. As a result, two projections are included for diminishing the visualization error due to the projection.

Departing from different moments of the nineteenth and twentieth centuries, countries reveal peculiar paths. The UK was the most precocious country to take off in the 1780s.

According to Rostow, France was following in the 1810s, the United States and Germany in the 1840s, Sweden in the 1860s, Japan and Russia in the 1880s, Italy and Canada in the 1890s, Australia (and Portugal) in the 1900s, Argentina, Turkey and Brazil in the 1920s, Mexico in the 1940s, Iran, India, China, (and Taiwan, not included in the sample) in the 1950s, and Thailand (and South Korea, not included in the sample) in the 1960s.

Results show relative positions among countries, for each of the clusters that represent each decade. As neighboring means high similarity, and distance means the opposite. Figure 1 reveals that dissimilarity increased throughout the last half a century, but the first decade of the new millennium reveals convergence. Benefiting from the explanatory capability of MDS visualization technique, one can see that these neighboring positions changed over time.

In the 1960s the proximity was so close that it becomes difficult to distinguish the names of the countries in both shots. Points belonging to this decade (shaded circles) are less spread out than those for the 1970s, and the dissemination of shaded squares (points corresponding to the 1980s) clearly increased, indicating greater dissimilarities. The 1990s (empty squares) still reveal large dispersion, but the new millennium decade (points signaled by “x”) shows an area of concentration. Of course all economic history of these 19 partners is contained in this chart, but one chart cannot reveal the whole set of political, economic, and financial features that were relevant in explaining these results. Similarity among the 19 sampled Rostowian countries was very high, in spite of the different moments when they experienced their take-off. In the 1960s the Russian Federation was dissimilar. The same may be said of China, which clearly was out of the “cloud” of points, when Mao’s political concept of a “permanent cultural revolution”. Increased dissimilarity in the 1970s allows for an observation of neighboring sets. In the context of the Cold War isolation atmosphere, Nikita Khrushchev ruled a centrally-planned economy that would enter a stagnation phase under Leonid Brezhnev’s presidency (1964-1982). China was again clearly out of any cloud under Mao’s special communist vein. However, the Russian Federation was much less dissimilar than in the decade before. This is the time when the Cold War attained its climax, thanks to weaponry production and space research competition. India, Turkey, and Thailand were also quite dissimilar.

In the two first decades the pioneers, UK, France, and US, were quite apart, but the nearest cloud of countries was made of successful followers in late nineteenth century, such as Sweden, Canada, Italy, and Japan. This indicates that recent historical events such as Japan’s defeat in the Second World War were not detrimental enough to prevent that country from occupying a position close to its nineteenth-century industrializing partners three decades after the end of the conflict and two decades after the end of the American

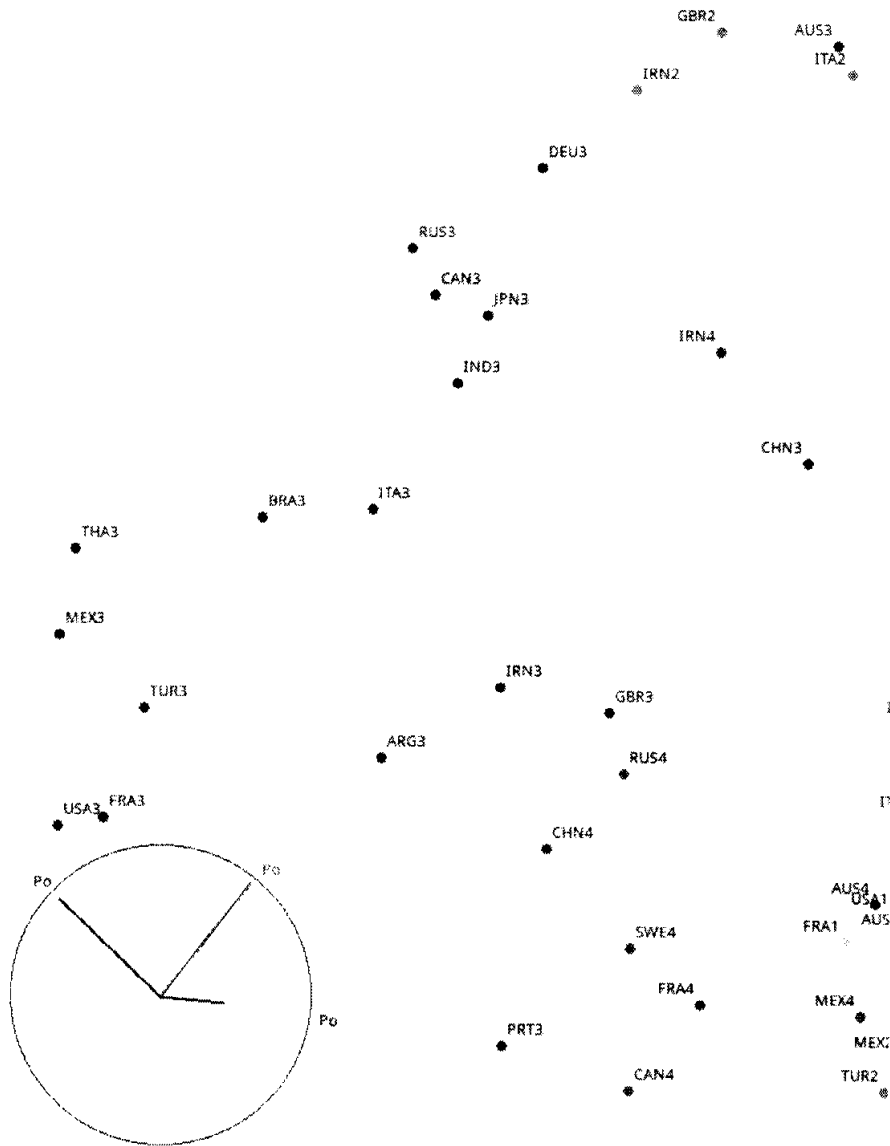


Figure 1. MDS map with $m = 3$ using cosine-correlation for the 19 countries and 5 decennial periods, based on the selected variables.

military occupation of Japan, which lasted until 1953. In fact, the presence of American multinationals and the quick industrial recovery in Japan led this country to achieve a position quite close to other old partners, something that historians have labeled as “a Japanese miracle”.

This means that the remaining partners are the late-comers in industrialization. They were so close in the 1970s that they formed a club of similarity comprising Argentina, Turkey, Brazil, Mexico, India, Thailand, and the pioneer Germany, which remained halved in the context of the Cold War. Iran occupied a separated position and was an outlier, in a phase

when oil became a decisive energy raw material, and the 1973 oil shock benefited this oil producer's relative position, by damaging the most industrialized countries' GDPs.

Rotating the MDS plot confirms that the most scattered decade diagram is that of the 1980s (shaded squares), for the set of indicators that were selected to capture human development indices. The 1980s are represented in the MSD map as a surprising period, in comparison with the two previous decades. The Russian Federation continued dissimilar, in a time of stagnation and warring in Afghanistan. The decade had large economic fluctuations, as business cycles brought prosperity and recessions. Argentina's divergence certainly reflects the GDP per capita difficulties (the President of Argentina Raúl Alfonsín, elected in 1983, started negotiations on a new program with the IMF), Thailand achieved considerable economic growth along open market lines, Turkey followed an adjustment that was very successful, Mexico recovered from the 1982 crisis (as the second oil shock benefited oil producers), and China moved toward reforms to introduce de-collectivization of agriculture, market mechanisms, and business entrepreneurship in the late 1980s thanks to de-nationalizations.

Divergence in the 1990s is also clear, but it is quite difficult to assert that it increased. China, Canada, and Iran can illustrate the cloud dimension of this decade. Japan no longer has a separate position, reflecting its growth miracle (slowing growth only in the late 1990s). The new millennium, however, would bring a different experience. Convergence prevailed, and neighborhoods changed, forming nodes of similarity. This fact may recall the literature on clubs of convergence, but this is not the issue examined in this paper.

Did the relative proximities among countries change throughout the process? What national cases were the most similar when looking at the entire half century of economic growth?

For capturing the path as a whole, Figure 2 represents the MDS map using cosine-correlation distances among the 19 partners. It is possible to say that China is a case on its own, and had no close partner (even Russia was quite apart). European partners and Japan followed quite closely throughout time, and can be distinguished from India and Thailand. As one may see, the largest dissimilarities occur with China, Russia and Brazil, Thailand and India. Other partners are closer among them, making clear the cluster of Italy, France, Canada, Japan, and the UK. In the same way, Australia, Turkey, Iran, and the US continued closer.

Rotating the MDS map estimated for the whole period, one can confirm the proximities among Italy, Canada and Japan, France and the UK. It also exhibits the similarity of two oil producers, Mexico and Iran.

The exercise might finish here, but it is worth mentioning that conclusions are confirmed

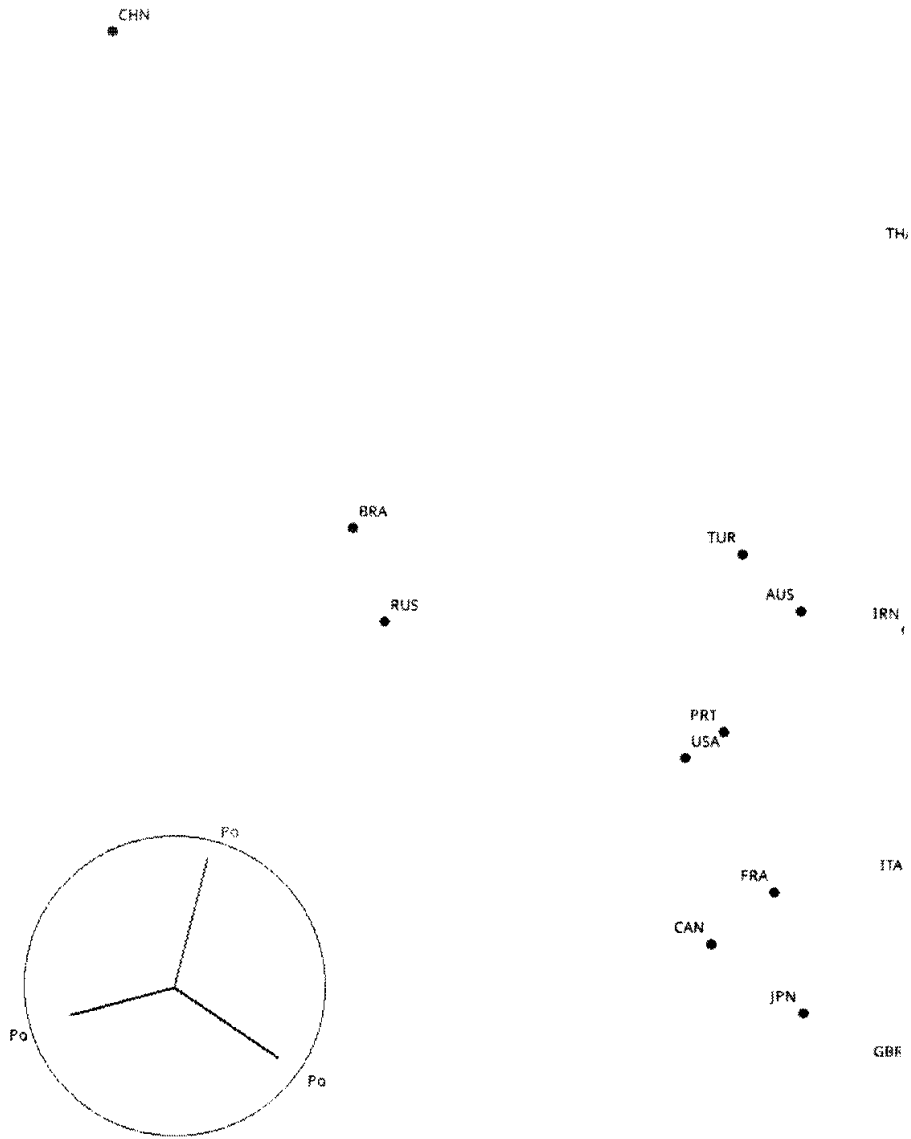


Figure 2. MDS map with $m = 3$ using cosine-correlation for the 19 countries and the whole period, based on the selected variables.

if Euclidean distance is used. All estimations were repeated, this time using Euclidean distance, to make the exercise more robust and conclusions more reliable. They are available in the next four Figures. Figure 3 presents a MDS chart for the 5 decennial periods with $m = 3$ using Euclidean distance for the 19 countries.

Previous conclusions seem to be clearer. The usual different position for Russia stands out, even in the period of deep reforms away from communism and central planning, but almost non-existent nowadays. Argentina's problems can explain divergence in the 1990s, isolating this country in the figure.

In the same way, one may distinguish a cloud of similarity, comprising countries that

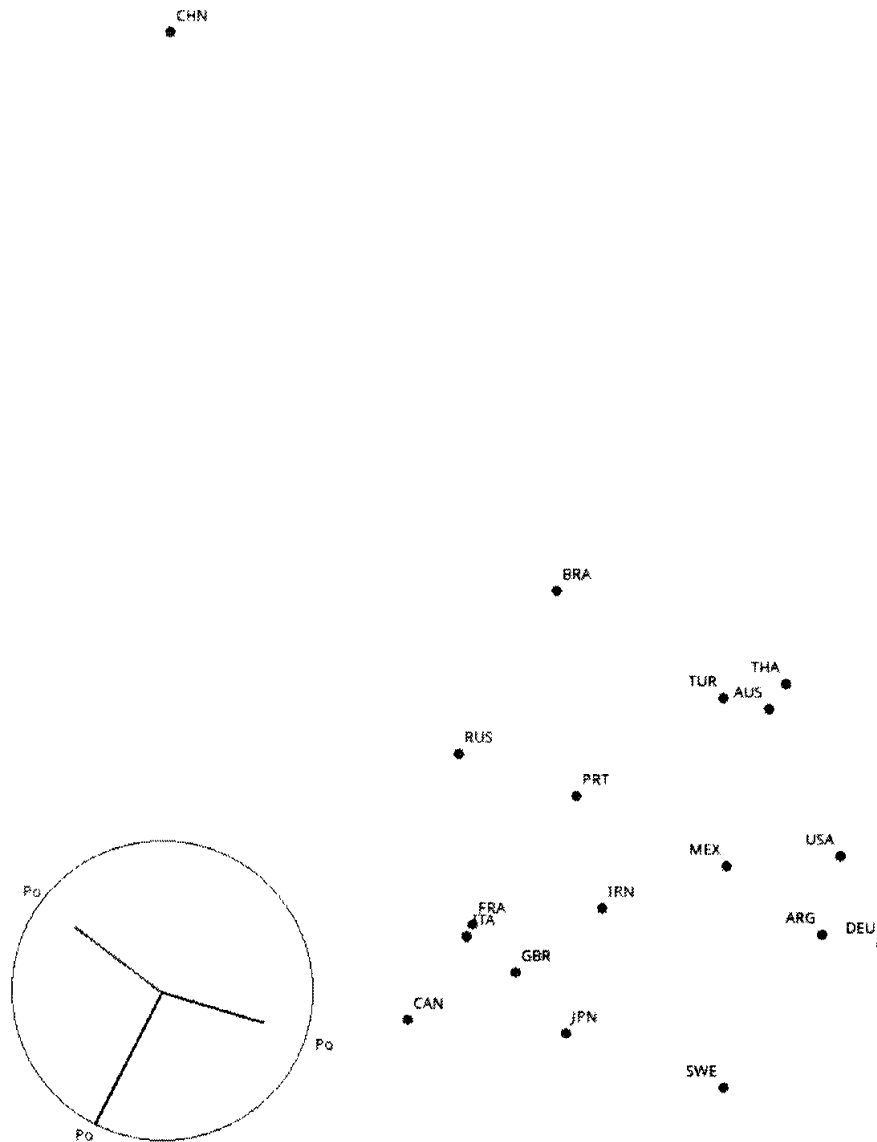


Figure 4. MDS map with $m = 3$ using Euclidean distance for the 19 countries and the whole period, based on the selected variables.

ones that experienced take-off in the first half of the twentieth century. As five decades are the right time for Rostowian maturation, they all should be classified as developed mass-consumption regions, according to Rostow's 1960s expectations. Considering the large regional asymmetry between these two groups of countries, this appears to be an inaccurate conclusion. Similarity between the Italy, France, UK, and Japan, reveals that convergence is incomplete, a reading that is quite evident rotating and zooming the MDS plot. Argentina and Mexico are close partners, as well as Sweden and Russia.

The conclusions stand, using both the cosine-correlation (1) and the Euclidean distance

(2). At the same time, the image of the 19 Rostowian analyzed countries, when depicted on a plane after MSD calculations, appear similar. The tight proximity matters for the UK, Italy, France, and Japan - the 8 forerunners of the late eighteenth early nineteenth centuries. This may reflect the European growth difficulties in the new millennium. For other forerunners proximity (and similarity) was the rule.

The new-millennium European crisis, combined with successful Asian industrializations, and the extension of market mechanism to a global world free of central-planning systems, offers hopeful new opportunities for convergence. Global market disclosure revealed high uncertainty in the Old World, particularly because of instability in the Euro zone.

5. Conclusions

In the last five decades economics has received vast contributions on the theories of economic growth and development, thanks to the Neoclassical paradigm based on the use of productive resources with marginal decreasing returns and the challenges against some of its hypotheses. The conclusion that convergence was the rule because free capital movements could cancel the effects of decreasing marginal returns was triggered in the contributions of the 1980s and 1990s. This paper seeks to check the available data, taking the opportunity of challenging the 1960's Rostowian model for the spread of industrialization and modernization along five stages of economic growth.

Adopting the MSD methodology proved to be appropriate for this purpose in calculating distances among partners, thanks to a long database of significant explanatory variables for economic growth. The results obtained are less optimistic than the most optimistic Neoclassical views. Economic growth dynamics are very difficult to analyze, as they involve patterns that depend on a large mix of factors including globalization, business cycles, and the respective external shocks. According to conditional convergence theories, some decades were enough to eliminate disparities, as 70 years were enough to close the distance to steady state. Convergence stands mainly among European partners, some European offshores (Canada, USA, and Australia), and Japan. On the other hand, Brazil, Argentina, Turkey, Iran, India, Thailand, (and China), in spite of colonial experiences (or historical European influences) were mainly converging in the first decade of the new millenium, but still remain out of the close neighboring in the MSD plots after five decades have elapsed since the 1960s, the moment when historical evidence most supported the hope of the convergence hypothesis. Having experienced their take-off in successive moments before the 1960s (as they all are considered by Rostow, 1964), the end of the bipolar Cold War world in the late 1980s, and the multiple crises in the 1980s and 1990s prevented permanent global convergence. This confirms the pessimistic views on convergence theories expressed in the literature throughout

these two decades. Different from the first half of the last century, global disasters did not occur in the five decades described here in this paper.

The hopeful historians' literature earns confirmation. Rostow's, Vander Wee's and Fogel's convergence hypotheses deserve credibility. If there is a real threat of a global geopolitical turnover by 2040, it is a question that is beyond the scope of this paper. MDS confirms the first two decades convergence hesitation, and the new-millennium convergence.

In a different level this study formulates a methodology to constructs an assertive analysis tool capable of leading to assertive results, that somehow are not common in world economy modeling perspectives.

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