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The role of the National Innovation System in the growth of Latin American countries

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Abstract

In this paper we explore the role played by the National Innovation Systems of Latin American (LA) countries in their growth processes. This is done on comparative perspective to some East Asian Countries, which experienced a virtuous recent development process. We Explore the role of two main development strategies/trajectories, one based on the exploitation and export of natural resources and one based on the diversification of productive structures and exports. Though these constitute extreme stylized cases that are not necessarily mutually exclusive they show be be instructive for understanding the different patterns that can be observed in Latin American countries along the last decades. The results suggest that the relatively less positive economic performance of LA countries was partly due to the limited development of their NIS. While some countries of the region seem to fit into the picture of a "curse of natural resources", most present a growing relevance of these types of products, together with a relatively diversified productive structure, important efforts to strengthen the NSI and social improvements. But they seem not to be able to completely escape a weaker version of the natural resources curse, which could easily become a middle income trap.

Keywords: National Innovation Systems; Latina American countries; diversification; natural resources; growth.

Introduction

This paper explores the role played by the National Innovation Systems of Latin American (LA) countries in their growth processes. While in the aftermath of the second world war they were considerably richer than South East Asian (SEA) Countries such as South Korea, Taiwan, and Singapore, starting from the 1980s LA countries had much lower and much more volatile rates of growth than SEA countries. Although the determinants of growth are many and often interacting, two differences between the two groups of countries stand out as potential determinants of their relative growth perfomance since the 1980s. First, the NIS of the SEA countries improved much more than those of the LA countries; second, LA countries had a much higher intensity of natural resources both in their output and in their exports relative to SEA countries. Thus, we intend to explore the potential impact of these differences on the relative performance of the two groups of contries while taking into account a number of other factors which are generally expected to contribute to economic development.

In what follows we will formulate the problem in terms of catching up strategies. In particular, we will compare two such strategies based respectively on (i) the differentiation of its output and its exports and on (ii) natural resources. The former strategy requires a country to improve its technology and innovation. The latter is based on exporting natural resources. This dichotomy is based on the literature according to which (i) Economic development requires the differentiation of the economic system, and (ii) a great abundance of natural resources in a country can be a curse rather an advantage. The literature on these two themes will be summarized in a subsequent section.

Catching up can be achieved either by increasing export variety or by selling natural resources. Increasing export variety requires the construction of an effective National Innovation System (NIS). In this paper we will represent the economic, social and NIS dimensions of the socio-economic system of LA countries and we will compare them to those of some successful SEA countries. By means of this comparison we will explore the role played by the NIS in the process of economic development of LA countries for the period 1990-2010.

1 Economic development, differentiation and natural resources

Although there have been forms of economic development since the beginning of human history in a modern sense economic development dates from the beginning of the industrial revolution (see Maddison, 2001) and coincided with the evolution of capitalist societies. The main features of the process of economic development which then began and which entailed a social transition, consisted of (i) the emergence of a new mode of production, sometimes called the factory system, characterized by the use of increasingly large machines and by larger firm sizes, and of (ii) the emergence of two new social classes, the capitalists, owners of capital, both financial and physical, and the working class, owning nothing and supplying the required labour force. The emergence of industrial capitalism has been brilliantly analyzed by Marx (1887).

The process of economic development which began with the industrial revolution led to unprecedented rates of growth which have been sustained if not amplified until the present time. However, while growth provides a quantitative estimate of the output of the economic system, this growing output was not obtained by a purely quantitative expansion of the economic system. On the contrary, the system itself underwent types of change which can be considered qualitative and which can be aptly described as transformations. Several scholars have identified a second or a third industrial revolution following from the first one but being sufficiently different from it to be classified separately. New technologies played a central role in all these revolutions but subsequent revolutions differed for the technologies which were central for them (Freeman, Louça, 2001). For example, textiles and the steam engine were central in the first industrial revolution while organic chemicals and electricity were central in the second one. Thus, the process of economic development was accompanied by profound qualitative changes in the structure of the economic and social system. Such changes were not just epiphenomena of economic development but were some of its most central features which need to be taken into account when trying to explain long run processes of economic development.

The development which began with the industrial revolution was geographically very unevenly distributed. From its birthplace in the UK the industrial revolution started diffusing to some European countries and to the USA only in the second half of the XIXth century. It was only after the second world war that some non European countries started industrializing, led initially by Japan and followed later by Korea, Taiwan, Singapore and lately by China. During most of the period 1780-2000 the world distribution of output and of income became increasingly skewed towards the few countries which had already industrialized (Fagerberg, Godinho, 2005; Landes, 1998). It is only recently that this trend has been reversed with a growing share of world output and income going to emerging countries. However, this recent trend does not entail either for the present or for the foreseeable future a complete homogenization of the world economic system. In particular, capitalism is an example of a very dynamical system unlikely to ever find a position of rest, a feature aptly captured by Metcalfe's (1998) expression 'restless capitalism'. Schumpeter (1911) had clearly understood that a system which is always at equilibrium cannot have any economic development. Innovation is both the disequilibrating force and the main factor leading to economic development. Such restless nature would be very unlikely to disappear even if capitalism were to be replaced by a different type of system. Like the genie, innovation once out of the bottle cannot be put back into it. In a complex socioeconomic system innovation and diffusion are continuously operating but they are very unevenly distributed over the world economic system.

Relatively early after the beginning of the industrial revolution it started being evident that the way to grow consisted of industrializing. To the extent that the industrial system of the UK once created remained static, industrializing would have meant imitating what had already been done in the UK. However, even for very early followers and potential imitators the situation was never so simple. Although the presence of an early industrializer and the possibility to observe what that country had done could provide a blueprint to industrialize, the object of imitation was neither easy to imitate nor static. Abramowitz (1958) and Gershenckron (1962) pointed out that potential imitators needed to satisfy a series of conditions in order to be able to catch up. Gerschenkron maintained that latecomers could in principle have what he called the 'advantages of backwardness' but that to be able to exploit such advantages was neither easy nor automatic. Potential imitators could not follow the same path as the initial leader but needed to introduce some important institutional innovations. Furthermore, maintained that countries attempting to catch up needed to focus on new high growth, technologically advanced sectors rather than on the more mature ones. This prescriptions was in stark contradiction with the textbook one most economists would have given then and even more recently. Yet it was precisely this prescription that was followed by Germany, the first country to successfully catch-up with the UK, and by the most successful developers of the second half of the XXth century (Japan, Korea, Taiwan, Singapore, China). According to Abramowitz in order to catch-up follower countries needed to have technological congruence and social capabilities. The former term referred to the similarity of the follower and of the leading countries. The latter referred to the capabilities other than industrial and technological required to catch-up. In fact social capabilities are both an attractive and ill-defined concept. However, as we will see later, it anticipated the more precisely defined concept of the co-evolution of technologies and institutions.

1.1 Catch-up, a simplistic and mono dimensional concept

Although widely used in the literature on development the concept of catch-up is extremely reductionist. It implies that LDCs should try to imitate a model of economic system which has already been established by developed countries (DCs). If referred to the complete structure of the economic system such imitation process is impossible and never carried out in real life. Any country, whatever its level of development, has a socioeconomic system constituted by many interacting components. Even if each of these components were homogenous and if one could represent it by one variable, the system would have many dimensions. The concept of catch-up can be easily applied only if we reduce the whole socioeconomic system to one dimension, for example GDP per capita. In this case we could calculate the distance of each country with respect to the richest one, which would then constitute the frontier. However, although some general trends can be identified as countries move towards higher levels of development, no two countries ever become identical in all the components of their socioeconomic system. Even if a trend towards higher levels of education seems to be a common component of development, the institutions used to achieve this objective vary greatly amongst different countries.

As a consequence we are going to use an expanded version of catching-up and we will represent the heterogeneity of the socio-economic systems of the countries concerned by means of several dimensions. For each dimension we will define a frontier, based on the highest possible value of the given dimension. The dimension we are going to choose in this paper are economic, social and innovation system. In turn, each dimension will have several components. As suggested within the economic dimension we pay special attention to output and export variety and to natural resources. The chosen dimensions are not independent but interacting subsystems in the complex socio-economic system of the country. For example, if education and the NIS are considered possible co-determinants of the growth of GDP per capita we can imagine to represent the process of catching-up as movements towards the frontiers of education and of the NIS, movements which would entail a corresponding movement towards the frontier of GDP per capita. Although here we seem to be implying that a movement towards the frontier of education or of the NIS is a cause of economic development, as represented by GDP per capita, we are simply saying that these three dimensions co-evolve. The precise mechanism by which this co-evolution can occur will be discussed later. For the time being we are simply saying that we reinterpret the process of catching-up as being multidimensional, consisting of several interacting dimensions, or components, of the socioeconomic system. The dynamic interactions of these dimensions give rise to the overall process of economic development. In particular, in this paper we are going to focus on the role of export variety and of natural resources as possible co-determinants of economic development.

We represent a socioeconomic system by means of multiple components and represent the process of economic development as a series of movements towards different related frontiers. While this outcome is in principle possible, it does not seem to inevitably occur, as demonstrated by the persistence of development traps (e.g. middle income trap) and of large disparities in income per capita at the international level, the opposite can occur with some LDCs not only catching-up but leapfrogging the most advanced countries (Perez, Soete, 1988; Fagerberg, Godinho, 2005; Lee, 2013). The distinction between catch-up and convergence is important but it will not concern us in this paper. Due to the sample chosen and to the period studied we cannot find any case of complete convergence or of leapfrogging.

1.2 Differentiation and economic development

There is a general consensus that Innovation was one of the main factors leading to the sudden acceleration of growth that occurred since the time of the industrial revolution (Freeman, Soete, 1997; Freeman, Louça, 2001; Mokyr, 1990). Technological and organizational innovations transformed pre-existing sectors and created new ones. As a consequence, the quantitative growth in per capita GDP observed since that time was accompanied by a considerable degree of structural change. There is disagreement amongst economists about whether structural change was just an epiphenomenon or a co-determinant of economic development. We favor the latter interpretation because it is the uneven distribution of innovations, both in geographic and in product space, that gives rise to the uneven patens of growth of different industrial sectors. However, once innovations have given rise to a particular economic structure, by adding or modifying industrial sectors, such structure affects future economic development for a considerable period of time. Furthermore, the creation of new industrial sectors cannot occur without the creation of new institutions or the adaptation of existing ones. In other words, economic development occurs through the co-evolution of technologies and institutions (Nelson, 1994; Saviotti, Pyka, 2013).

In the emphasis we place on structural change we rely not only on evolutionary economics but on a number of contributions from different research traditions ranging from structuralists, such as Chenery (1960), Kuznets (1957), Prebisch (1949), Singer (1950), Myrdal (1958) and Furtado (1964) to the Cambridge (UK) school of economics (Pasinetti, 1981,1993) and to the work of enlightened neo-classical economists (Baumol, 1967, Acemoglu, Zilibotti, 1997). Furthermore, as it will be seen later, we not only stress structural change but the direction it takes. Our model predicts that under a wide range of circumstances economic development will give rise to a growing differentiation of the economic system, or, in other words, to a growing output variety.

The previous considerations imply that the macroeconomic level of aggregation at which we observe growth is affected both by the microeconomic level and by the intermediate level at which sectors and co-evolving institutions are located. These meso (Dopfer) levels of aggregation are essential in understanding economic development. A mechanism by which structural change can act as a co-determinant of economic growth has been proposed by Pasinetti (1981, 1993), according to whom the imbalance between saturating demand and continuously growing productive efficiency can lead to a development bottleneck which can be overcome by the creation of new sectors. Thus, the increasing differentiation of the economic system can compensate for the growing inability of incumbent sectors to create employment. Although Pasinetti's assumption of a complete saturation of demand can be excessive (Chai et al, 2010) the conclusion that an increasing differentiation of the economic system can sustain long run economic development has been confirmed by a growing number of papers, both empirical and based on models (Funke, Ruwhedel, 2001; Imbs, Wacziarg, 2003; Saviotti, Pyka 2004, 2008, 2013; Hidalgo et al, 2007, 2009; Saviotti, Frenken, 2008; De Benedictis 2009; Felipe, 2012,).

In particular, Saviotti and Pyka (2013) maintain that the economic development which occurred since the industrial revolution can be characterized by three trajectories, each consisting of the rise in a variable:

- Trajectory 1: increase in productive efficiency
- Trajectory 2: increase in output variety
- Trajectory 2: increase in product quality and in (intra-sector) differentiation

The concept of trajectory is amongst the most important in evolutionary economics (Nelson, Winter, 1977; Dosi, 1982). However, it is generally used to indicate trajectories occurring within particular technological paradigms or technological regimes. The trajectories we refer to here are much longer lasting and they occur at higher levels of aggregation. Typically such trajectories can occur for national economies but they are common to whole economic systems, although the speed at which various countries proceed along them can vary considerably. They are not specific to any particular technology, although new technologies are likely to emerge because they allow a faster movement along these trajectories.

The above considerations have interesting implications for catching-up by LDCs (Saviotti 2003). If world output variety keeps increasing we can expect that, although individual countries tend to specialise, this specialisation cannot remain constant and must reflect the new goods and services emerging in the world economy. In general we expect national variety to increase when world variety increases. If countries aim at keeping an almost constant share of world income, or, in the case of developing or industrialising countries to catch up, then the ratio of national to world output must remain at least constant or increase in the case of catch-up. In fact, increasing output variety without increasing export variety would not be very effective. However, while export variety can be a very successful development strategy it is not the only possible one. Some countries can compensate a limited increase in output variety (Trajectory 2) with a higher increase in output quality and differentiation (Trajectory 3). Other countries can develop, in the restricted sense of moving towards the economic frontier, by exporting natural resources. Unfortunately, due to data availability amongst these three strategies we can only map the ones based on export variety and on natural resources.

If they are to lead to complete catch-up, strategies based on export variety or on export quality and internal differentiation require innovation and increasing knowledge intensity. While it may be possible to add textile exports to an economic system producing only agricultural commodities, the subsequent addition of more complex exports inevitably entails an increasing education, knowledge and R&D intensity. As Fagerberg and Verspagen (2007) have shown, since the 1980s only countries which succeeded in constructing a proper NIS were able to fully catch up with, or sometimes to leapfrog DCs. Hence, we expect that countries which are successful in achieving catch-up by export variety are likely to have done so by constructing a well working NIS. On the other hand, countries relying on natural resources as a catch-up strategy do not seem to have always created adequate NISs. In fact, there has been a literature, going under the name of 'The curse of natural resources', which argued that development based on natural resources would inevitably lead to problems. In what follow we will (i) analyze the concept of National Innovation System (NIS) and the role it can play in export variety and in economic development and (ii) describe the literature on 'The curse of natural resources'.

1.3 The NIS and economic development

The concept of the National innovation System (NIS) was introduced by Freeman (1981, 1987) and by Lundvall (1985, 2007), but both of them considered Friederich List a possible precursor. List did not mention innovation but focused instead on the need to construct a national production structure. List was concerned with the way in which Germany could develop in a period in which Britain was the leading industrial power. He stressed that the government needed to play an important role to build national infrastructures and institutions, a concept which has subsequently gained a considerable importance in the strategy of Import Substitution Industrialization (ISI).

Thus, the concept of the NIS was established in opposition to the assumption that all countries could and would follow the same path towards economic development. Innovation is not carried out in the same way in different countries, for example by allocating different amounts of resources to R&D and to higher education. On the contrary, countries differ in a number of dimensions, and such differences tend to persist in the course of time. There is evidence of persistent asymmetries in a) the production structure (Archibugi, Pianta, 1992), and in b) the institutions used to achieve a). This does not mean that each country can do whatever it pleases and can continue to do so indefinitely, but that although common constraints on economic development exist, each country adapts to them in different ways depending on its endowments and institutions. In other words, these asymmetries persist in presence of common trends (see R&D, education, etc) for relatively long periods of time. The related concept of sectoral innovation systems (Malerba, 2002, 2004, 2005) implies that the inter-sectoral variation in innovation patterns is typically greater than inter-country variation for the same sector. However, while the given sector may be implemented in a similar way in different countries, the specialization pattern different countries adopt in the course of their economic development can vary considerably. The sectors which drove the development of the UK, Germany, Italy or Japan are different (Malerba, 2005) a point made without reference to innovation systems by Porter (1990). An interesting recent example of the role that the choice of sectors can play in development is that of short life cycle sectors in the catching-up of Korea and Taiwan (Lee, 2013).

In spite of the presence of sectoral innovation systems, in a general sense the idea that all countries could carry out any activity in exactly the same way seems strange. The introduction of a new activity into a national economic system cannot occur in an institutional vacuum but needs to be integrated within the existing institutions of the country. In general we expect technologies to co-evolve with institutions (Nelson 1994). Furthermore, the nature of the knowledge used in productive activities is such that it cannot be easily moved (Lundvall 2007) thus giving rise to a certain inertia. In summary, we can expect the evolution of NISs to be subject to path dependence. However, we cannot from that infer that no important change can occur in NISs. The catching-up of countries such as Japan, Korea, Taiwan shows that NISs can be constructed and modified at particular times ad exert a powerful effect on the development of the countries concerned (Lee 2013; Fagerberg, Verspagen 2007, Fagerberg, Shrolec, 2008).

Perhaps the most general characteristic of the concept of NIS is the interactivity of its components, a characteristic which justifies its name. Thus, an NIS is constituted by its components and by their interactions. However, scholars who studied the NIS differ as to the types of components and interactions that need to be taken into account. This has given rise to a distinction between a narrow and a broad conception of the NIS. The narrow conception focuses predominantly on the research system as constituted by R&D, higher education, by firms and by their interactions. The broad conception takes into account a wider range of institutions and interactions, such as, for example government and financial institutions. Although this distinction is not between two discrete entities it is possible to detect in particular studies a greater emphasis towards either one of the two categories. For example, amongst the earliest and most complete studies of NISs, the one by Nelson (1992) tends to be more closely related to the narrow conception while the ones by Lundvall (1992) or by Edquist (1997) tend to be closer to the broad conception. In this paper we will map the NIS by means of a restricted number of variables closely related to research and to higher education. In this sense it would seem as if we are choosing the narrow definition of the NIS. However, we will use the chosen representation of the NIS together with other dimensions of the socioeconomic system of the countries concerned. So our overall approach is closer to the broad conception of the NIS.

In particular, we will study the impact of the NIS on the creation of a growing export variety. Our paper is indebted to some papers which have tried to place the study of the NIS on a quantitative basis.

Fagerberg and Shrolec (2008) carried out a PCA of the data they gathered about a large number of dimensions of several countries, the NIS, governance, political and openness dimension. Of these factors the one which was by far the most important potential determinant of GDP per capita is the NIS. The other factors were not closely related to the level of economic development of the countries concerned. Although it did not have this objective, the paper by Fagerberg and Shrolec seemed to indicate that the narrow conception of the NIS captured the parts of it that were more closely related to economic development. In this paper we represent the socioeconomic system of the countries studied, but we choose ourselves the variables which constitute each dimension. We do this because we study a longer period than Fagerberg and Shrolec and the data availability vary greatly for the different variables we use.

Dutrenit and Puchet (2011) and Dutrenit (2012) have been dedicating considerable effort for exploring the connection of structural characteristics of Latin American countries and their NSI, especially considering the relevance of critical masses in STI capabilities. A major finding in this ongoing research program is the strong correlation and co-evolution of structural and NSI dimensions. The variables chosen and the graphical representation in this paper are directly inspired by these contributions.

In our paper we will study the role played by the NIS in the economic development of LA countries with special reference to the period 1990-2010. Most LA countries had relied heavily in the past on the export of natural resources, including agricultural outputs and minerals. In fact in our paper we are comparing two development strategies based on export variety and on natural resources. The former cannot be carried out without innovation while the latter does not necessarily entail innovation and may in some cases create negative inducements to innovate. The sometimes problematic nature of a development strategy based on natural resources has given rise to the expression 'The curse of natural resources', a theme to which we now turn.

1.4 The curse of natural resources

The term 'The curse of natural resources' was intended to describe the apparent contradiction between the wealth that can be generated by the exploitation and sale of natural resources and the observation that some countries that are very rich in natural resources did not benefit from or even were negatively affected by them. In particular, in a number of influential papers Sachs et al (1995, 1997, 1997, 1999, 2001) claimed that a large endowment of natural resources affected negatively the economic development of countries. Even before this modern resurgence the claim that the exploitation of natural resources could negatively affect economic development had been made several times. According to Lederman and Maloney (2007, p. 16) even Adam Smith had observed that 'natural resources are associated with lower accumulation of human and physical capital, lower productivity growth and lower spillovers'.

The need to overcome an excessive dependence on the production and export of natural resources had a powerful impact on the economic development of Latin America and on the emergence of import substitution industrialization (ISI). In the 1950s Prebisch (1959), among others, popularized the idea that the terms of trade of natural resource exporters would experience a secular decline over time relative to those of exporters of manufactures.

As a consequence, the development of a manufacturing industry, initially protected by trade barriers, was advocated.

A number of other reasons were posed to explain the curse of natural resources. First, a high dependence on natural resources may result in high levels of export concentration, which may lead to higher export price volatility and hence greater macro volatility. Second, rents arising from resource extraction may lead to institutional failures (Easterly and Levine 2003). Third, imperfect international capital markets allow countries experiencing commodity price booms to overborrow, eventually requiring policies that restrict growth when credit dries up during the inevitable downturns (Manzano,Rigobón 2001).

Recent research raised doubts about the generalized existence of a curse of natural resources. In a book edited by Lederman and Maloney (2007) several chapters criticize previous results about the curse based on two reasons. First, changes in the data used or in econometric techniques can lead to different results, implying either that the effect of natural resources on economic development is not necessarily negative or that it can even be positive (Lederman, Maloney 2007b; Manzano, Rigobón 2001, 2007). Second, historical studies show that the development of countries such the USA, Canada, Australia and even the UK at the time of the industrial revolution benefited greatly from the exploitation of natural resources (Wright, Czelusta 2007). The most general conclusion reached in these further studies is that natural resources do not inevitably lead to a curse. Amongst the countries rich in natural resources there are both 'good' and 'bad' ones. The crucial difference which allows some countries to escape the curse is learning. Countries which coupled the exploitation of natural resources with the development of higher education, technology and innovation in the same fields tended to develop better than those which relied on existing technologies and did not invest in learning activities. In some countries (Chile, Australia) a period of inefficient exploitation was followed by one in which improved technology allowed both an expansion and a more efficient exploitation of the resources.

In spite of the previous conclusions there are a number of countries which clearly show the symptoms of the curse of natural resources. Countries such as Nigeria, Venezuela and Angola in addition to a very high degree of polarization of their exports towards natural resources, in this case oil, show a persistent lack of investment in infrastructures and education not to mention learning activities. LA countries sit in an intermediate position between the best and the worst NR countries. Long before the advent of import substitution industrialization (ISI) LA countries had largely relied on NRs for their exports. In fact, the introduction of ISI was due to the perceived need to build up a "complete" industrial structure and, thus, reduce the weight of NRs in the economic systems of LA countries. Some LA countries have created substantial manufacturing industries (Brazil, Argentina, Mexico) and non negligible innovation systems, but they still have a problematic combination of NRs, manufacturing and NIS. It must be observed that the 'good' NR countries not only had learning activities together with NRs, but had learning activities focused on NRs. Furthermore, none of the countries which were the best developers of second half of the XIXth century (Japan, Korea, Taiwan, Singapore) were rich in NRs. Thus, the relationship between NRs and NIS can be expected to exert a powerful influence on the development of a country.

2 The NIS of LA countries

Several scholars have used the National Systems of Innovation approach to characterize and analyse the structure of actors and institutions and the linkages of innovation in Latin American Countries (Katz and Bercovitz, 1993; Cimoli, 2000; Cassiolato, Lastres and Maciel, 2003; Lopez, 2007; Dutrenit *et al.*, 2010; Lemarchand, 2010).

Although Latin America is a very heterogeneous region in terms of development levels and of the characteristics of their National Innovation Systems some common features can be pointed out. The first is the very high level of inequality. Even with some progress in the last ten years, Latin America is still the most unequal region of the world.

Up to the end of the II World War countries of the region specialized in export of agricultural goods and minerals and their scientific and technological infrastructure was relatively poor. Only Argentina had a high educational level.

After the end of the war LA countries went through major institutional changes which deeply affected the NSI. Import Substitution Industrialization – ISI - in most large and medium sized LA countries brought important technical capabilities to these countries. Also, in the 1950s, specific public institutions - National Research Councils - were established in most LA countries with the objective of increase the funding and coordinating S&T activities.

As the ISI effort was based on a significant involvement of government organizations, a large number of public enterprises were set up and these firms established R&D labs which proved to be an important source of technological and innovation activities. Also several new public research institutions were created in almost all Latin American countries. This effort of setting up public research activities included agricultural technologies. For example, in Brazil, in the 1970s, the Brazilian Agricultural Research Enterprise (EMBRAPA) was created with the objective of coordinating R&D activities in the agricultural sector and expanding them beyond the traditional export crops such as coffee and sugar cane. In Argentina, in the 1950s the National Institute of Agricultural Technology (INTA) was set up.

However, apart from the issue of technological infrastructure and despite all the planning effort, very limited results regarding fostering innovation and R&D activities by firms were achieved by the end of the 1980s. During the ISI period, more than the 80% of Science and Technology (S&T) expenditure was funded by the government and performed within their institutions (Katz, 2000). Business-performed research and development activities were mainly carried out by large public firms.

Studies analysing technological behaviour of LA firms in the 1970s and 1980s indicate that low levels of internal R&D activities were accompanied by very weak links to government-owned industrial research institutes and universities. The three main productive actors that were active during industrialisation have had very specific technological and innovation strategies (Erber 1980 and 1981, Cassiolato 1992, Katz 2006):

1. State-owned public utilities (particularly in the oil industry and public utilities) found it necessary to create their own engineering and R&D departments in order to study the specificity of local demand and assess the nature of the locally available natural resources. A large number of public R&D and engineering centres emerged, representing the core of the National System of innovation during that period.

2. Foreign Trans-National Corporations (TNCs), which brought with them new products, processes and organisational technologies unknown in the domestic production environment, concentrated their technological efforts in 'adapting' product designs, as well as process and organisation technologies to local conditions.

3. Large, locally owned conglomerates concentrated mostly in the raw material processing industries, producing very standardised 'commodities' such as pulp and paper, iron and steel, vegetable oil, copper, petrochemicals etc. They did not significantly promote efforts to develop 'in-house' technical capabilities with the aim of increasing added domestic value or begin to specialise in more complex or unique products.

The institutional transformations of the 1990s associated with liberalization and privatization brought about major changes in the pattern of production specialization of most LA economies.

In the new globalized economy LA countries found it very difficult to be inserted in so-called global production networks that in fact only integrated US, Europe and Japan with

Asian economies, particularly China. According to several studies made at the UN Economics Commission of Latin America and Caribbean (Katz and Stumpo, 2001; Katz 2006) there has been a shift in favor of non-tradable sectors (those producing telecommunication, energy or financial services, for example) as well as toward natural resource-processing industries producing iron and steel, petrochemicals, nonferrous minerals, vegetable oil, pulp and paper, etc.

In fact it is possible to say that, as part of the integration of LA countries in the globalization process, two separate patterns appear to have emerged, that of Central American countries and that of South America. On one hand, South American countries have intensified their specialization in natural resources and standardized commodities. These are now highly capital-intensive industries with low domestic value added. In this case, Latin American firms act as price takers.

On the other hand, countries such as Mexico and the Central American nations have benefited from the access to the USA economy and attracted TNC subsidiaries to perform assembly activities based on cheap labor. (Katz, Stumpo 2001). Electronic and garment *maquiladoras* (assembly plants), as well as automobile producers, have grown quite rapidly in the last 25 years in these countries.

In short, the pattern of production specialization of LA economies and their linkages with the rest of the world are going through major transformations which point out to a low knowledge content of specialization patterns and a retreat to resource-based processing industries, to nontradable goods and services, to labor-intensive electronic and garment maquiladoras, and to vehicles and transport equipment. The impact of such changes in the National Systems of Innovation of LA countries is bound to be significant.

Below is a summary of the conclusions of several analyses of LA National Innovation Systems (Castaldi et all 2004; Katz 2006; Cassiolato el at 2003; Cimoli at al 2009):

- Deteriorating education system with proportionally lower output of engineers;
- Stagnation or decline of enterprise level R&D and other learning activities;
- Weakening of science-technology infrastructure (with some exceptions);
- Very low level of investment;
- Slow development of modern telecommunication;

- Very weak local electronic industries;
- High and growing specialization in low income elasticity goods;
- Low level of local and global S&T and R&D networking;
- Decreasing domestic value added and losses of important parts of production chains.

3 Empirical Study

3.1 Methodological Notes

To analyze the role of NIS in the development of LA countries we represented the socioeconomic systems of some LA countries and of some very successful South East Asian developing countries by means of the three dimensions, economic, social and NIS. Each of these three dimensions was represented by a series of component variables. Table 1 presents the component variables used and the respective data sources.

Table 1. Dimension and component variables used to represent each country and data sources

ECONOMIC		SOCIAL		NIS	
GDP per capita	UNSD[1]	1/Gini Index	World Bank	GERD % of GDP	Unesco[8]
GFCF/GDP	UNSD	Health expenditure per capita	World Bank	Education Expenditures % of GDP	Unesco
FDI/GFKF	UNCTADSTAT[2]	Life Expectancy at Birth	World Bank	Number of students in tertiary education (per 100,000 inhabitants)	Unesco
(M+X)/ GDP = openness	UNCTADSTAT	HDI (Human development index)	UNDP[6]	WIPO Patents (per thousand inhabitants)	WIPO[9]
High-Tech Exports / manufactured exports	World Bank[3]	1/Unemployment rate	IMF[7]	Scientific Papers (per million inhabitants)	World Bank
Export NR/Total exports	UNcomtrade[4]				
Export unrelated variety	UNcomtrade				
Production unrelated variety	INDSTAT[5]				

Source: Own elaboration

[1] United Nations Statistic Division (http://unstats.un.org)
[2] United Nations Conference on Trade and Development (http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx)
[3] http://databank.worldbank.org/data/home.aspx
[4] United Nations Commodity Trade Statistics Database (http://comtrade.un.org/db/) – Natural Resources are defined as the sum of the following commodities in the SITC Rev.3. classification: 0 (food and live animals); 1 (beverages and tobacco); 2 (crude materials, inedible, except fuels); 3 (mineral fuels, lubricants and related materials); 4 (animal and vegetable oils, fats and waxes); 68 (non-ferrous metals)
[5] United Nations Industrial Development Organization
[6] United Nations Development Programme - Human Development Reports (http://hdr.undp.org/en)
[7] International Monetary Fund - World Economic Outlook Database, October 2012 (https://www.imf.org/external/pubs/ft/weo/2012/02/weodata/index.aspx)
[8] United Nations Educational, Scientific and Cultural Organization – Unesco Institute of Statistics (www.uis.unesco.org)
[9] World Intellectual Property Organization (http://ipstatsdb.wipo.org/ipstatv2/ipstats/patentsSearch)

The variety indicators are based an entropy. A detailed methodological discussion related to the construction and interpretation of different types of variety measures (related, semirelated and unrelated variety) is presented in Saviotti and Frenken (2008). In short, the entropy measure both for output (production) and export unrelated variety is computed by:

$$UV = \sum_{i=1}^{n} p_i \log_2\left(\frac{1}{p_i}\right), \qquad (1)$$

Were p_i is the share of sector i in total exports of a country. For unrelated variety we use the share of the sectors at the one digit level. Thus, this entropy measure increases with an increase in the number of sectors n and with the evenness of the distribution of shares.

Each dimension of each country is graphically represented within a polygon combining the corresponding component variables for three specific years, 1990, 2000 and 2010. For constructing the graphical representation each variable has been built by subtracting the minimal value for that variable among all countries and years considered in the sample and afterwards dividing it by the respective maximum value resulting from the first step. Thus, for each variable, the overall minimum will be zero and the overall maximum will be one. Formally:

$$x_i = (a_i - a_{\min})/(a_{\max} - a_{\min}). \qquad (2)$$

3.2 The evolution of Latin American and East Asian countries

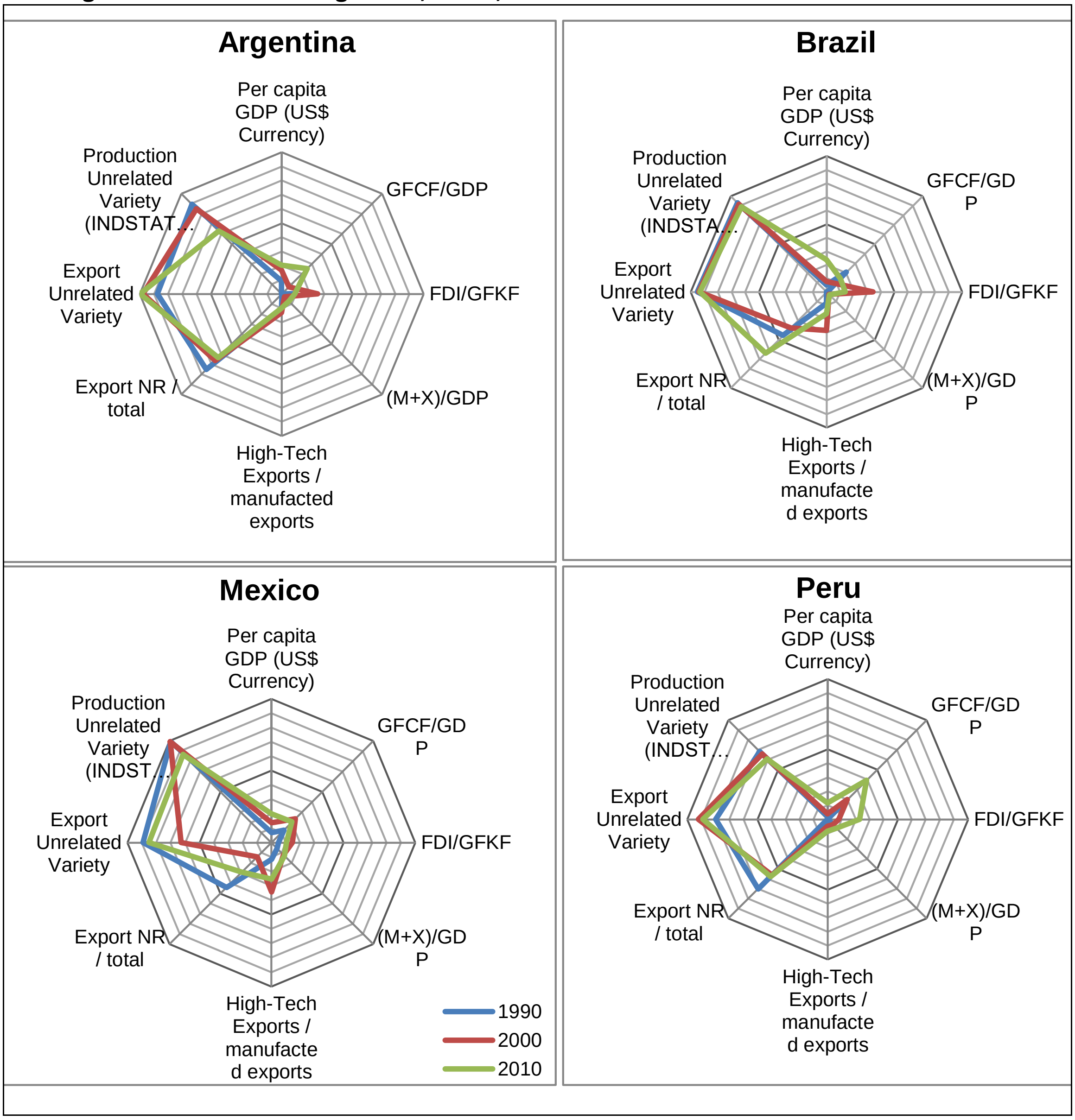
In the following subsections we briefly present the data for the three dimensions for the selected set of countries and afterwards bring present some interpretation.

3.2.1. Economic Dimension

Considering the economic dimension we can sort the Latin American countries into two main groups. The first group is presented in figure 1 and includes Argentina, Brazil, Mexico and Peru. These countries show a low but growing per capita GDP, a low gross fixed capital formation and a small and diminishing foreign direct investment.

The degree of openness (ranging from 0,23 for Brazil to 0,47 for Peru in 2010) seems relatively low, in particular relative to the small SEA countries. All four countries also present a relatively low and falling export share of high-tech exports. On the other hand, they show a medium to high share of natural resources in total exports. In spite of the low relevance of high-technology sectors, LA countries show relatively high levels of both export and production unrelated variety.

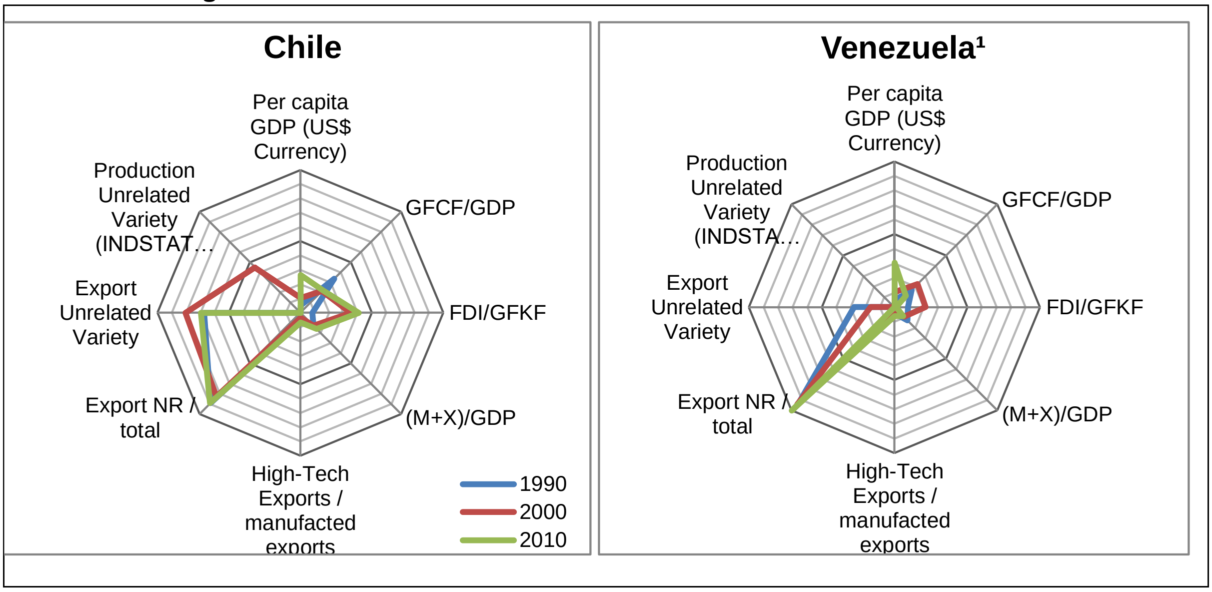
Figure 1. Evolution of Argentina, Brazil, Mexico and Peru in the economic dimension



Source: Own elaboration

The other two Latin American countries, Venezuela and Chile, can be classified into a second group. While they are similar to the other Latin American countries in terms of per capita GDP, GFCF/ GDP and FDI/GFKF, both show a slightly higher degree of openness and a lower relevance of high-tech exports. What distinguishes these two countries is an even higher export share of natural resources. In the case of these two countries this seems to translate into a relatively less diversified production and/or export structure, which show a falling tendency over the two decades.

Figure 2. Evolution of Chile and Venezuela in the economic dimension



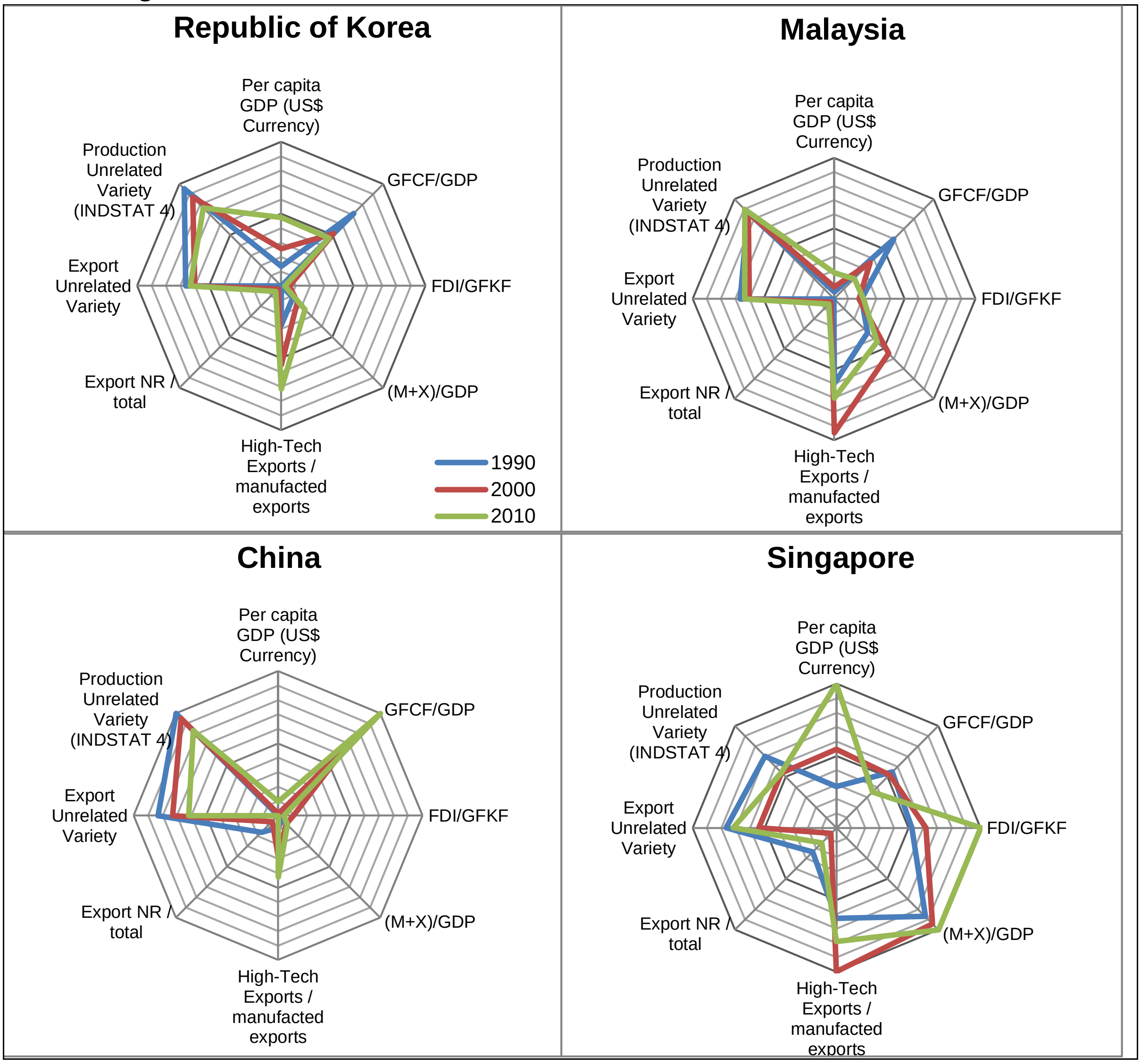
Source: Own elaboration

[1] There are no data available for Venezuela for Production Unrelated variety, since the original output data are not available in the INDSTAT database for that country

For comparison we present the evolution of four selected East Asian Countries, which experienced relevant growth along the last decades. Since the graphs have been constructed for a relative comparison of all countries (including the LA ones), we see that the outstanding relevance of some dimensions for some country "biases" the graphs for most other countries. This is for example the case of Singapore for the share of FDI in GFKF (87% in 2010), the share of high-tech exports on total exports (63% in 2000) and the degree of openness (3,94 in 2010). Especially the last variable is closely related to the size of the country, which makes comparison difficult with big countries. Another outstanding example is the role of investment as a driver of growth in China (45% of GDP in 2010).

Apart from these specificities, all SEA countries present similar features. All present a relatively high or fast growing (China) relevance of high-tech exports over total exports and a very low importance of natural resources exports. The development trajectory of all these countries have been linked to some degree to the focus on high value added sectors and international markets. Korea, Malaysia and China show a high level of both production and export variety. The very small size of Singapore possibly limits the potential scope for differentiation of the production structure, favoring a concentration in some high value added sectors. At the same time it we can note that the output variety of all four countries has been decreasing between 1990 and 2010, possibly indicating a re-specialization following differentiation (Imbs, Wacziarg, 2003).

Figure 3. Evolution of Selected East Asian countries in the economic dimension



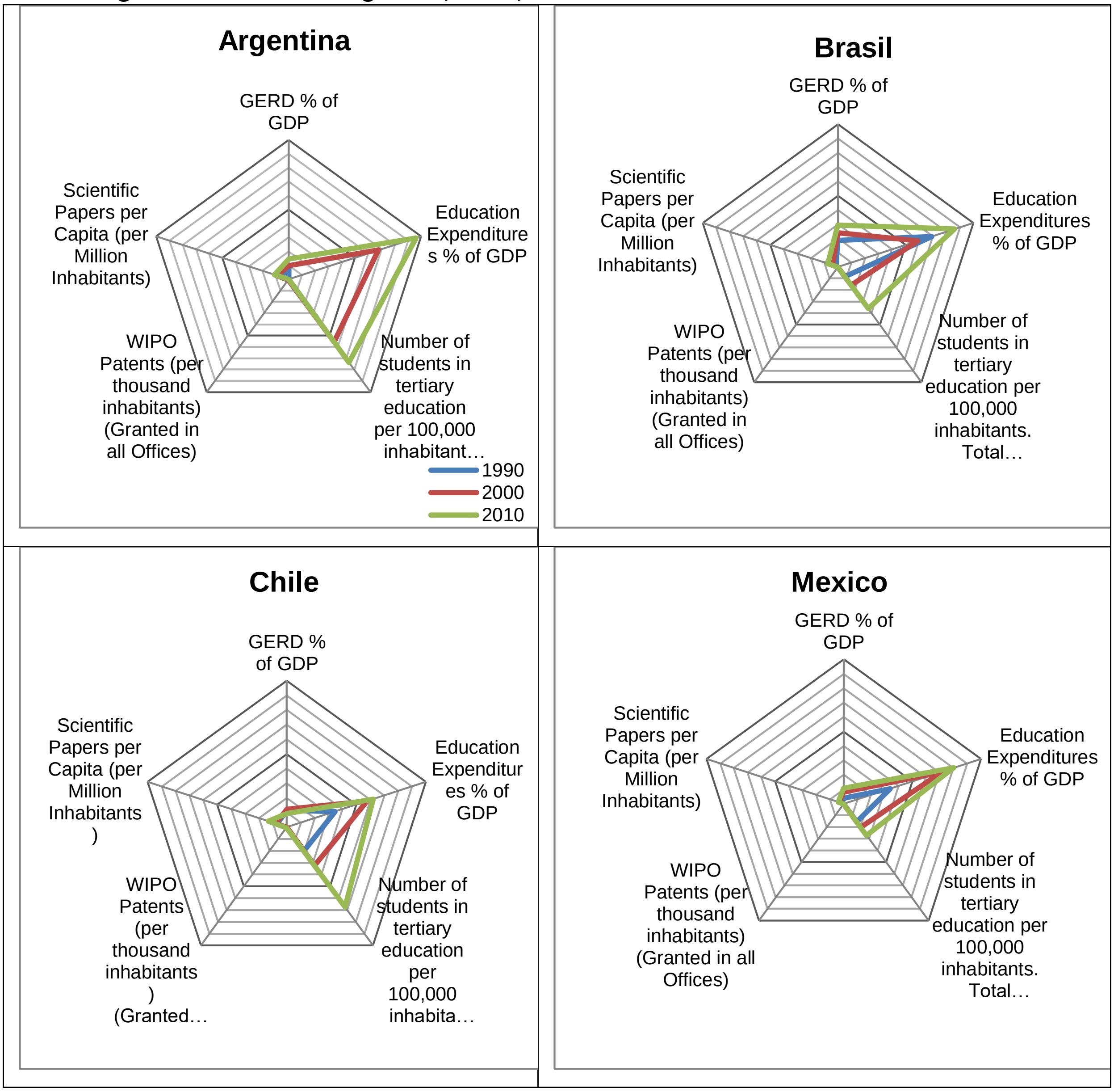
Source: Own elaboration

3.2.2. Innovation Systems Dimension

Considering the Innovation System dimension the six Latin American countries can be sorted into two groups, although they do not substantially differ. If compared to Korea and

Singapore, Argentina, Brazil, Chile and Mexico show a low level of scientific publications per million inhabitants , of patents per thousand inhabitants and of the share of GERD in GDP. However, although relatively low, the LA countries are increasing (except for Chile). Argentina, Brazil and Mexico also show high to very high levels of expenditures in education as a percentage of GDP, leading to a growing share of population in higher education.

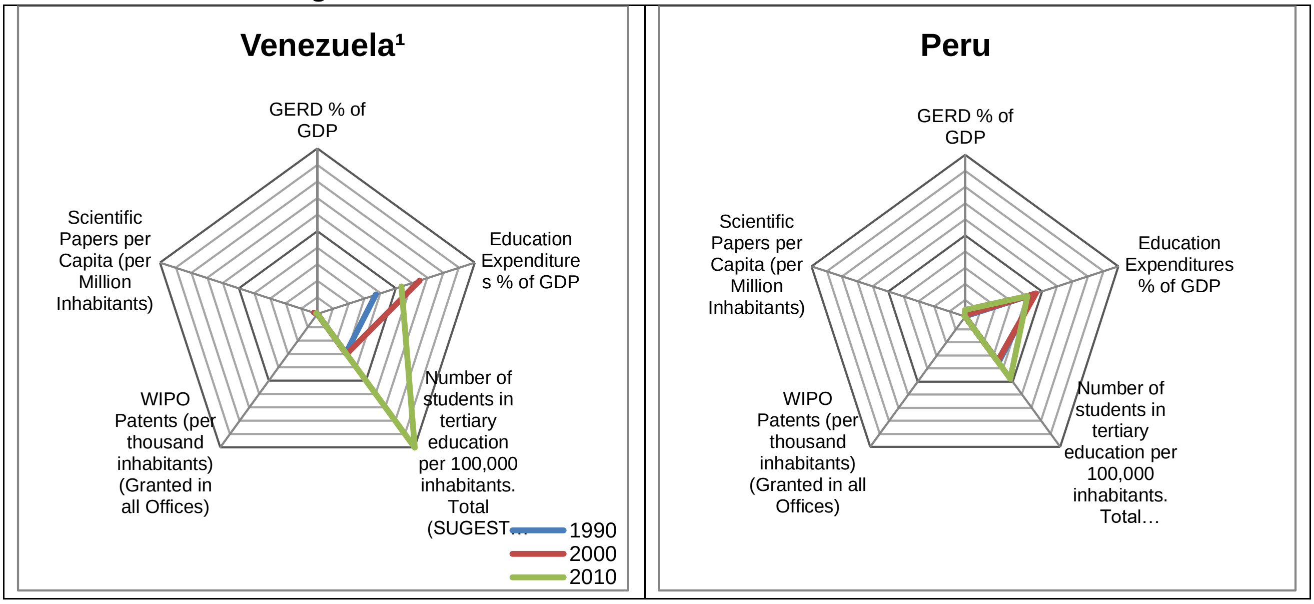
Figure 4. Evolution of Argentina, Brazil, Chile and Mexico in the NSI dimension



Source: Own elaboration

Again, two LA countries, Venezuela and Peru, stand out from the rest other LA countries both in terms of output variables (both countries) and in terms of the overall investment in R&D (no GERD data are available for Venezuela). On the other hand, education Expenditures as a percentage of GDP are average and the number of students in tertiary education per inhabitants is especially high for Venezuela. Official statistics, validated by Unesco, suggest that this country jumped from 2809 students in higher education per 100 thousand inhabitants in 2000 to almost 8500 in 2010, making Venezuela the positive "outlier" for this variable[1].

Figure 5. Evolution of Venezuela and Peru in the NSI dimension



Source: Own elaboration
¹ GERD for Venezuela not available

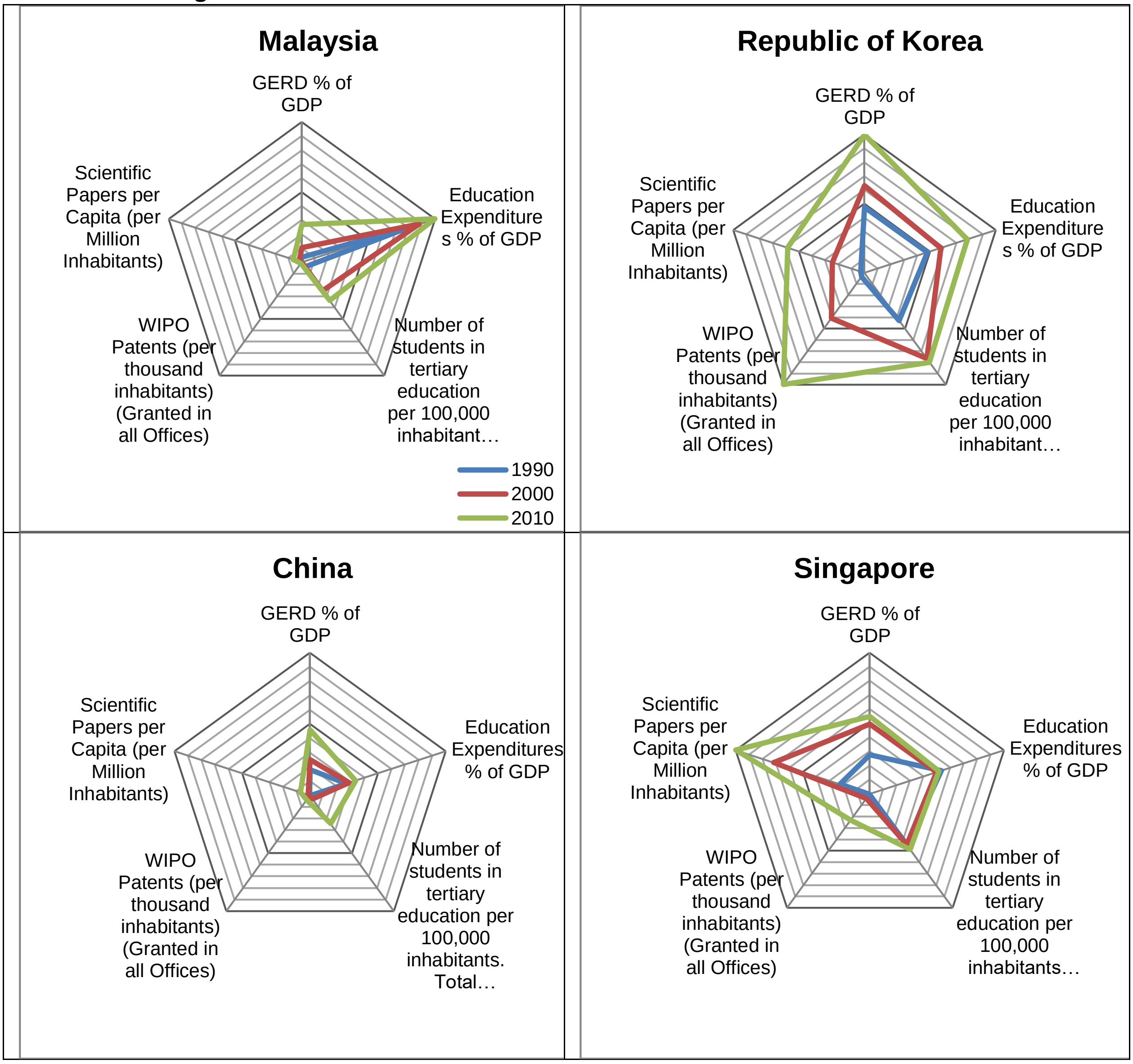
The four East Asian countries show a rather differentiated mosaic. At the one hand, China and Malaysia seem to present a similar pattern, since they present five indicators with medium to low values and the main difference is the expenditures in education over GDP, which is much higher in Malaysia. Especially the output variables are very low for both countries. Of course China stands out as a relevant player in scientific and technological

[1] We were not able to identify to what extend this sharp increase is due to effective efforts made by government and to what extend methodological issues might influence the values.

output in the recent period, but since the variables are relative to total population they end up so low.

On the other hand, Korea and Singapore rank first respectively for the output variables patents and scientific papers. But, while Singapore shows average values for other NSI dimensions Korea presents a consistent and fast growing effort and performance in all dimensions.

Figure 6. Evolution of Selected East Asian Countries in the NSI dimension



Source: Own elaboration

In general terms, it is also interesting to identify some consistency in the trajectory each NSI evolves along the period. All of them show consistent expansion over the two periods in some variables, especially those which already had some significance at the beginning of the period (1990), while others remain relatively stagnated along the whole period. This is the case in education variables and GERD for some LA countries, China and Malaysia, GERD and output variables for Singapore and all variables for Korea. At the one hand this underlines the path-dependent evolution pattern of the NSI and, on the other side, may be an evidence of the difficulty to incorporate and achieve substantial results in fields that historically received less attention.

3.2.3. Social Dimension

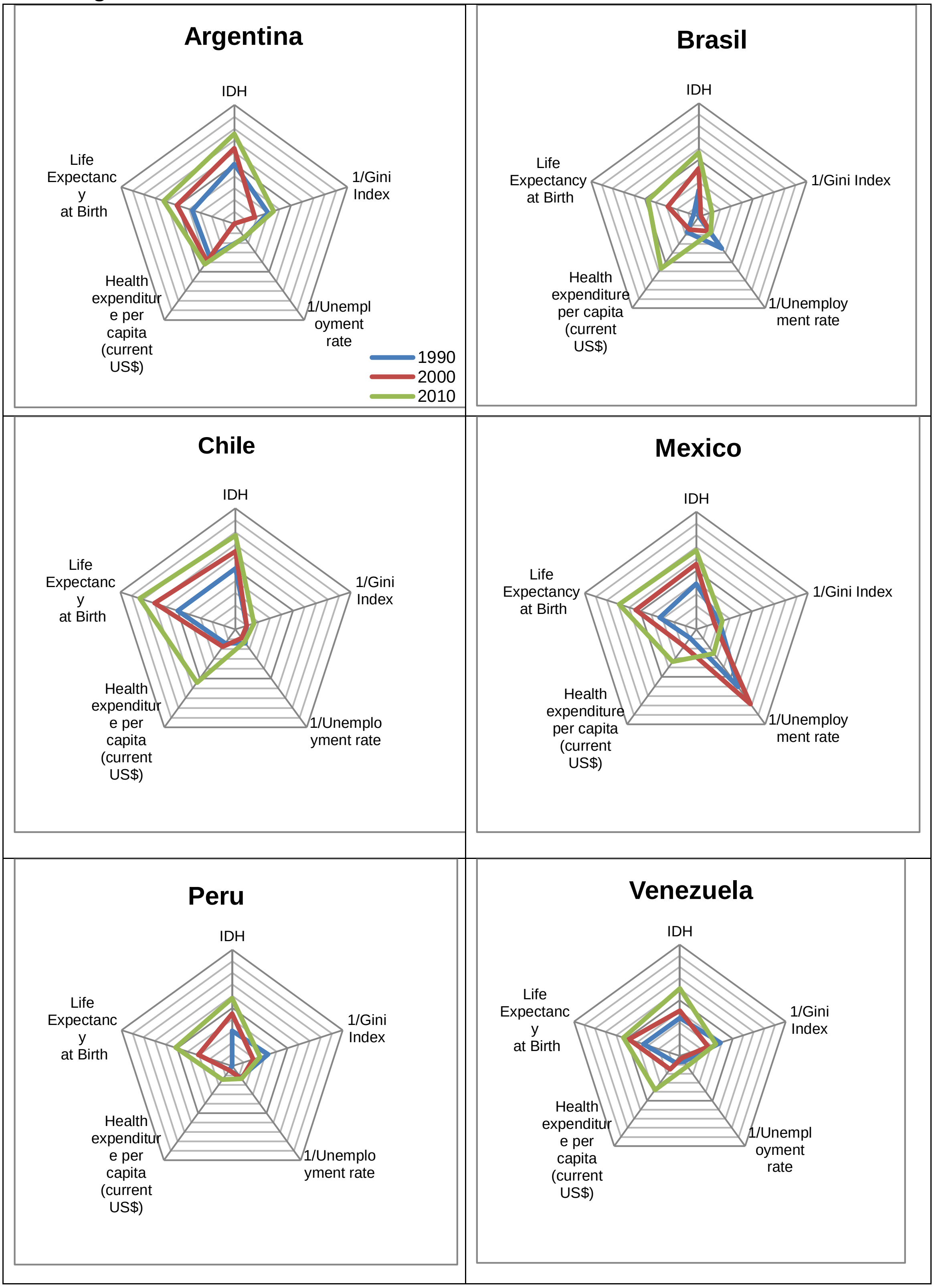
The social dimension presents the most diversified picture with some sharp variations over the period. The relatively low level of LA countries for the 1/Unemployment statistic is probably artificially low due to the exceptionally high value of Singapore (Fig 7). In fact, in a historical perspective the unemployment rates for the Latin American countries in 2010 are relatively low, ranging from 8.6% in Venezuela to 6.7% in Brazil and to 5.4% in Mexico.

A positive performance can be observed also in the case of income distribution along the last decade. Although some experienced an increasing income concentration from 1990 to 2000 (Argentina, Peru and Venezuela) all of them showed relevant improvements from 2000 to 2010, especially Brazil that started from a very high concentration level.

The statistics related to health also show relevant improvement for all LA countries but starting from different levels. Thus, Argentina, Chile and Mexico present average levels of expenditures in health but relatively high life expectancy. On the other hand, Brazil and Venezuela expanded quickly investments, which is likely to have improved life expectancy.

Considering the Human Development Index to be a good summary indicator for the social dimension we can conclude that the different development trajectories followed by the Latin American countries have been associated with relevant improvements in terms of social welfare.

Figure 7. Evolution of Selected Latin American Countries in the Social dimension

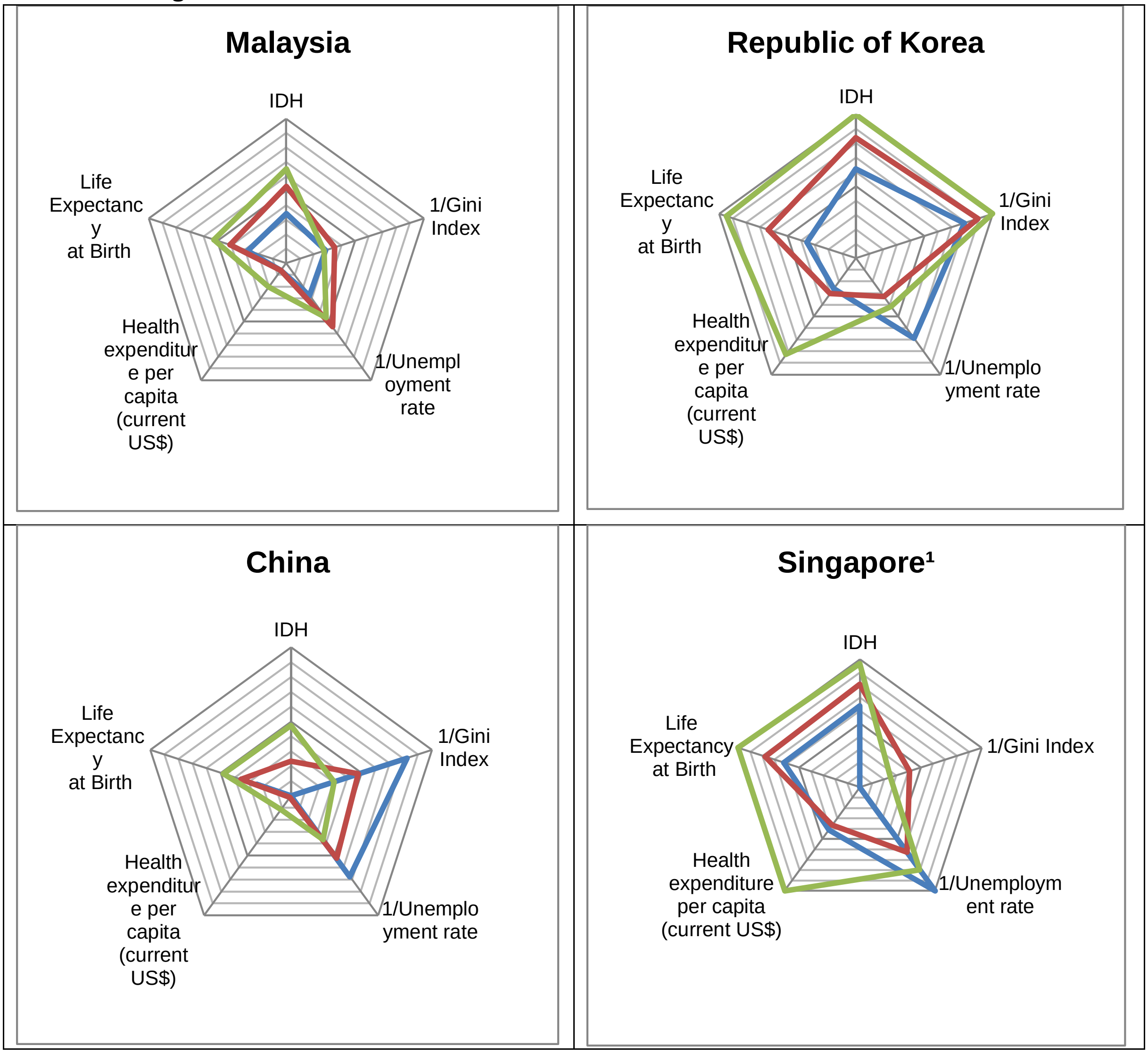


Source: Own elaboration

Similarly to the NSI dimension we can sort the four East Asian countries into the same groups. Considering the statistics for 2010 China and Malaysia present very similar figures. Average HDI, life expectancy and unemployment and beneath the average values for health expenditures and 1/Gini. On the other side, Korera and Singapore show very high levels of expenditure in health, life expectancy and Human Development Index, accompanying their good performance in the other dimensions considered in this study (economic and NSI).

But, with the exception of Korea, we highlight that the development trajectory of these countries along the last decade has not been so virtuous if we consider income distribution. Income concentration slightly increased moderately since 2000 in Malaysia and in Singapore and much more rapidly in China, where both income concentration and unemployment increased sharply. To what extend this tendency may impose some limitation on the development model of these countries remains an open question.

Figure 8. Evolution of Selected East Asian Countries in the Social dimension



Source: Own elaboration

[1] Gini index for Singapore for the year 1990 not available

4 Summary and Conclusions

The SEA countries we have chosen do not form a homogeneous sample. South Korea and Singapore are the most advanced, having not only caught up with DCs but having leapfrogged some of them either in the economic dimension (GDP per capita) or in the NIS dimension. Malaysia made considerable progress but is more of an intermediate case between the above SEA countries and LA countries. China started catching-up from a lower level of development and much later than either Korea or Singapore. As consequence, when we compare LA and SEA countries we will refer mostly for the latter to Korea or Singapore, which are much closer to the relevant frontiers.

LA countries started the 1990-2010 period with an economic dimension not very different from that of SEA countries, but SEA countries developed more rapidly, especially Korea and Singapore. In the economic dimension two differences stand out: first, although LA and SEA countries started the period in a very similar situation, SEA countries grew more rapidly than LA countries; second, LA countries have a negligible dependence on natural resources relative to LA countries. Such dependence is almost absent for Korea and probably exaggerated by the re-export of processed natural resources in the case of Singapore (See Lederman, Maloney, 2007).

On the other extreme with an increasing concentration and dependence on the exports of natural resources we find the cases of Venezuela (especially oil) and Chile (copper, other minerals and fishing products). The size of the internal consumer market in the case of Argentina, Brazil and Mexico may help to foster a more diversified industrial structure. Additionally, the regional economic integration and free trade treaties make other LA countries the most important export destination of manufactured products (in the case of Mexico also the NAFTA countries).

This yields those three countries an output and export variety similar to that of developed countries. But, the relatively low relevance of high-tech exports suggests that these countries present an evenly distributed export structure along the one digit product groups, but with a greater relevance in each of those groups of products of low and medium value added. On the other side, a high output variety but only a medium-high export variety and the concentration in high-tech segments in the case of SEA countries suggest that these countries already underwent a diversification of their productive structure and tend to focus on high value added segments in international trade.

LA and SEA countries differ much more considerably in the NIS and Social (SOC) dimensions. In each of these dimensions SEA countries show both a higher rate of growth and a more balanced content. LA and SEA countries started the 1990s with a similar NIS dimension, but SEA countries increased investment in their NIS much faster than LA countries. As a consequence at the end of the 1990-2010 period SEA countries have moved much closer to the NIS frontier than LA countries. LA countries differ also for the composition of their NIS. Whatever growth there has been in their NIS, it has been much more focused on education than on R&D and innovation relative to SEA countries. Thus, if we compare only the R&D and innovation components of the NIS, the relative lack of progress of LA countries has been even greater. On the whole the NIS of SEA countries is not only quantitatively larger but also more balanced than that of LA countries. From another perspective, the recent effort of some LA countries to connect the good performance in international trade of natural resources with substantial expansion in education investment may be interpreted as an effort to set up the basic conditions for a future qualitative jump, similarly to the SEA experience.

The social dimension of SEA countries is also much closer to the frontier and more balanced, with progress more evenly distributed amongst various components, than that of LA countries, although the latter show consistent improvements for most variables along the period.

We can now try to explain how the above differences could have contributed to the altogether inferior economic performance of LA countries. Clearly, SEA countries, and in particular Korea and Singapore, have outperformed LA countries in the NIS and SOC dimensions in the period 1990-2010. With regard to the NIS dimension, the greater investment by Korea and Singapore fits nicely with the findings by Fagerberg and Verspagen (2007) that from the 1980s onwards only countries which succeeded in constructing an adequate NIS could fully catch-up with DCs. Furthermore, Lee (2013) argues in a much more explicit and detailed way that the mechanism allowing Korea and Taiwan to fully catch-up or leapfrog consisted not only of the much greater investment in the creation of an NIS, but also in the choice of short lifecycle sectors in which catch-up could be expected to be easier. Lee also found that SEA countries' patents were less general than those of LA countries and more focused on the short lifecycle sectors in which they had decided to specialize.

Although we cannot from these findings conclude that the less positive development of LA countries' NISs was a cause of their worse economic performance during the period studied, it seems quite likely that the NIS is an important co-determinant of the co-evolutionary pattern of development of LA countries. What then becomes an important problem is why by the 1980s LA countries did not foresee the need to improve their NISs.

In comparing LA and SEA countries we need to take into account their differences relative to the social dimension. Here, as well as with the NIS, SEA countries score much better than LA countries and are closer to the corresponding frontier. In this case the comparison is more complex because it is not in general clear to what extent the SOC dimension can be just an effect or also a co-determinant of economic development. In a co-evolutionary perspective we suggest that the SOC dimension can be both an effect and a co-determinant of economic development. Although there is clear evidence that only advanced countries can construct well developed welfare states, it is equally clear that welfare states can themselves contribute heavily to economic activities. The increasing attention recently paid by China to pensions and health care as part of the rebalancing of its economy away from exports and towards internal consumption is a good example of the economic role of the welfare state. However, we cannot expect the welfare state to be a substitute for the construction of an adequate NIS.

A very important component of the SOC dimension is the Gini index, which measures the unevenness of income distribution in each country. In our graphs the Index is represented in inverse form to map more easily its progress towards the frontier. Here we can see that Korea and Singapore have much more even distribution of income than LA countries. The relationship between income distribution and economic development has been investigated in the literature but without definitive results (Alesina, Rodrik, 1994; Assa, 2011; Barro, 2008). It seems that the relationship is not linear. While a minimum level of inequality may be beneficial, a very high level is likely to be detrimental to economic development. Here it is worth mentioning that although in the past LA countries have been much more unequal than SEA countries, some recent redistributive policies introduced first in Brazil and later in other LA countries, seem to have had a positive effect on income distribution and possibly on economic development. We refer here to 'Bolsa Escola' and 'Bolsa Familia', two forms of income support initially given in exchange for the attendance at school of the children. These redistributive policies had the important effect of increasing the purchasing power of a large number (~40 millions in Brazil) of poor people allowing them to enter the lower middle class. In this case a more even income distribution is likely to have contributed to economic growth and development. That the relationship between income distribution and growth is non linear is confirmed by the rapid growth of the Gini index of China in a period of very fast economic growth.

In spite of the uncertainties about the relationship between income distribution and growth it seems very likely that a more even income distribution in the last twenty years, and especially in Brazil, can have contributed to economic development. The chronological sequence of the introduction of redistributive policies and of the improvement in income distribution seems to indicate that the latter has been caused by the former. However, we have to take into account that the first decade of the XXI century was also a period of high growth for Brazil, but mostly based on increasing dependence on the export of natural resources (Cassiolato, 2010). Has this favourable condition amplified the positive effect of redistributive policies? Since natural resources sectors are rather capital intensive and with lower inter-sectoral linkages, we cannot expect this to be a spontaneous process. The answer to this question would require a very detailed investigation which is outside the scope of the present paper.

In summary, this study confirmed in a different way that LA countries did not develop their NIS as much as SEA countries during the period 1990-2010. While the results of this study do not prove that this failure led to the lower economic performance of the former relative to the latter, they seem to indicate that such economic performance was partly due to the limited development of their NIS. The previous conclusion is reinforced by the fact that the spurt of growth occurred during the first decade of the XXIst century, largely due to a surge in demand for natural resources by China. What would be interesting to know is if this surge has been accompanied by a reinforcement of the NISs of LA countries. If not, one would have to conclude that LA countries, although not being affected by a serious form of the curse of natural resources, might be affected by a milder form. LA countries have created extensive manufacturing sectors but they cannot completely escape a weaker curse, consisting of the coexistence of an extensive but uncompetitive manufacturing sector and of an established and sometimes competitive natural resources sector. In this coexistence the manufacturing sector would be both enfeebled (exchange rate effect) and bailed out by the NR sector, while the NR sector could have very limited inducements to improve its knowledge intensity. It is not difficult to conclude that this weak form of the curse of natural resources, although less pernicious than the full one, could easily become a middle income trap.

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Appendix 1

Original statistics for the economic, NSI and social dimension of selected Latin American and East Asian Countries

Table A1. Economic dimension

Country	Year	Per capita GDP (US$ Currency)	GFKF/GDP	FDI/GFKF	(M+X)/GDP	High-Tech Exp. / Man. Exp.	Natural Resources Exp. / Total Exp.	Export Unrelated Variety	Production Unrelated Variety
Argentina	1990	4.330,35	0,14	0,09	0,15	7,95	73,80%	2,57	1,47
Argentina	2000	7.699,44	0,16	0,23	0,23	9,35	65,96%	2,81	1,43
Argentina	2010	9.162,13	0,22	0,09	0,40	7,45	63,01%	2,87	1,22
Brazil	1990	2.687,18	0,20	0,01	0,13	6,46	46,98%	2,75	1,50
Brazil	2000	3.696,30	0,17	0,30	0,22	18,73	39,82%	2,73	1,48
Brazil	2010	10.715,59	0,18	0,13	0,23	11,21	63,25%	2,71	1,46
Chile	1990	2.540,79	0,25	0,08	0,62	4,68	86,23%	2,09	n.a.
Chile	2000	4.876,64	0,21	0,31	0,61	3,41	80,77%	2,41	1,05
Chile	2010	11.887,71	0,21	0,36	0,74	5,45	86,57%	2,14	0,63
China	1990	359,62	0,25	0,03	0,28	6,44	20,87%	2,47	1,57
China	2000	956,69	0,34	0,10	0,44	18,98	11,56%	2,23	1,52
China	2010	4.514,94	0,45	0,04	0,48	27,51	6,32%	1,96	1,41
Malaysia	1990	2.510,69	0,33	0,17	1,41	38,21	6,50%	2,07	1,44
Malaysia	2000	4.005,56	0,25	0,16	2,20	59,57	9,16%	1,92	1,43
Malaysia	2010	8.372,84	0,20	0,19	1,77	44,52	11,06%	1,99	1,47
Mexico	1990	3.416,26	0,18	0,05	0,35	8,43	45,86%	2,61	1,56
Mexico	2000	6.369,89	0,21	0,13	0,58	22,45	18,82%	1,98	1,56
Mexico	2010	9.100,66	0,20	0,10	0,62	16,94	32,32%	2,51	1,44
Peru	1990	1.350,20	0,19	0,01	0,30	1,35	69,09%	2,39	1,27
Peru	2000	2.062,33	0,20	0,08	0,34	4,38	56,65%	2,68	1,25
Peru	2010	5.410,69	0,26	0,20	0,47	6,58	57,86%	2,60	1,20
Korea	1990	6.291,36	0,36	0,01	0,56	18,04	6,50%	2,07	1,52
Korea	2000	11.598,45	0,30	0,06	0,74	35,07	9,16%	1,92	1,45
Korea	2010	21.052,17	0,29	0,03	1,02	45,29	11,06%	1,99	1,35
Singapore	1990	12.873,82	0,31	0,46	3,45	39,89	27,45%	2,31	1,29
Singapore	2000	24.062,54	0,30	0,54	3,72	62,79	11,18%	1,77	1,13
Singapore	2010	43.783,11	0,25	0,87	3,94	49,91	19,54%	2,20	1,14
Venezuela	1990	2.389,43	0,19	0,09	0,61	3,94	89,79%	1,15	n.a.
Venezuela	2000	4.811,28	0,21	0,19	0,48	2,89	91,10%	0,88	n.a.
Venezuela	2010	13.589,01	0,17	0,02	0,46	5,05	95,97%	0,49	n.a.

Table A2. NSI dimension

Country	Year	GERD/GDP	Education Expenditures/GDP	Number of students in tertiary education per 100,000 inhabitants	WIPO Patents (Granted in all Offices)	Scientific Papers (per Million Inhabitants)
Argentina	1990	0,42	1,07	3.111,33	249,00	49,84
Argentina	2000	0,44	4,60	4.873,99	240,00	77,07
Argentina	2010	0,62	6,53	6.348,56	105,00	93,77
Brazil	1990	0,76	4,70	1.052,53	453,00	15,86
Brazil	2000	0,96	4,01	1.629,04	310,00	36,73
Brazil	2010	1,16	5,84	3.289,69	805,00	65,76
Chile	1990	0,51	2,36	1.958,87	57,00	62,94
Chile	2000	0,53	3,91	2.979,20	34,00	72,32
Chile	2010	0,42	4,20	5.855,33	171,00	113,88
China	1990	0,74	1,82	350,58	1.197,00	5,59
China	2000	1,00	1,94	589,55	6.446,00	14,82
China	2010	1,76	2,27	2.344,12	84.822,00	62,44
Malaysia	1990	0,22	5,60	685,30	20,00	12,80
Malaysia	2000	0,47	5,97	2.402,00	40,00	19,63
Malaysia	2010	1,07	6,80	3.101,72	516,00	55,39
Mexico	1990	0,22	2,31	1.602,45	132,00	12,31
Mexico	2000	0,37	4,86	2.005,28	224,00	29,72
Mexico	2010	0,48	5,45	2.558,86	424,00	36,77
Peru	1990	0,08	3,09	3.220,15	13,00	3,55
Peru	2000	0,11	3,14	3.142,95	9,00	3,07
Peru	2010	0,23	2,75	4.236,30	13,00	5,74
Korea	1990	1,82	3,26	3.843,24	2.554,00	27,22
Korea	2000	2,39	3,94	6.604,42	29.437,00	208,14
Korea	2010	3,74	5,33	6.864,59	76.019,00	492,80
Singapore	1990	1,09	3,62	3.982,90	20,00	189,62
Singapore	2000	1,89	3,38	3.997,22	254,00	602,40
Singapore	2010	2,09	3,49	4.330,16	1.855,00	838,65
Venezuela	1990	n.a.	2,53	2.766,20	63,00	15,95
Venezuela	2000	n.a.	4,42	2.809,37	14,00	21,18
Venezuela	2010	n.a.	3,63	8.496,43	26,00	10,07

Table A3. Social dimension

Country	Year	IDH	Gini Index	Unemployment rate (Percent of total labor force)	Health expenditure per capita (current US$)	Life Expectancy at Birth
Argentina	1990	0,701	46,28	7,60	616,89	71,50
Argentina	2000	0,755	51,11	17,13	688,97	73,72
Argentina	2010	0,805	44,49	7,75	741,83	75,63
Brazil	1990	0,590	61,04	4,28	316,36	66,34
Brazil	2000	0,669	59,96	7,10	265,19	70,14
Brazil	2010	0,726	54,00	6,74	990,39	73,10
Chile	1990	0,702	55,25	7,75	264,43	73,60
Chile	2000	0,759	55,26	9,71	323,59	76,82
Chile	2010	0,813	52,13	8,15	947,22	78,89
China	1990	0,495	32,43	2,50	21,31	69,46
China	2000	0,590	40,35	3,10	43,72	71,24
China	2010	0,689	45,96	4,10	220,88	73,27
Malaysia	1990	0,635	46,66	5,06	125,68	70,07
Malaysia	2000	0,712	44,33	3,00	128,12	72,14
Malaysia	2010	0,763	47,18	3,40	367,92	74,02
Mexico	1990	0,654	49,86	2,74	176,26	70,79
Mexico	2000	0,723	51,87	2,20	324,25	74,27
Mexico	2010	0,770	48,87	5,37	603,67	76,68
Peru	1990	0,619	45,30	8,30	100,33	65,55
Peru	2000	0,679	50,75	7,85	96,28	70,48
Peru	2010	0,733	48,14	7,88	268,76	73,76
Korea	1990	0,749	33,00	2,46	469,99	71,29
Korea	2000	0,839	31,24	4,43	543,06	75,86
Korea	2010	0,905	29,48	3,73	1.438,78	80,76
Singapore	1990	0,756	n.a.	1,78	725,17	75,58
Singapore	2000	0,826	42,48	2,68	648,25	78,05
Singapore	2010	0,892	48,10	2,18	1.733,02	81,64
Venezuela	1990	0,635	43,26	11,10	143,49	71,06
Venezuela	2000	0,662	47,50	14,01	273,12	73,27
Venezuela	2010	0,744	44,77	8,60	663,39	74,13