

# **A Taxonomy of National Innovation Systems: Lessons from an exercise comprising a large sample of both developed, emerging and developing countries**

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## **1. Introduction**

The aim of this paper is to put forward a taxonomy of national innovation systems (NISs). With that purpose in mind we will first implement a technique for mapping innovation systems that was developed by Godinho et al. (2003). Such mapping allows one to compare directly different NISs, by visualizing in bi-dimensional space the graphic pattern of the relevant dimensions of each innovation system. Next the quantitative output of this NISs mapping will be used as the basis for performing a cluster analysis in a second step. The resulting country groupings will be analysed for identifying the major factors separating different NISs types. This will be the basis for a definition of a possible NISs taxonomy.

In the paper eight major dimensions along which innovation systems develop are highlighted. These dimensions include market conditions; institutional conditions; intangible and tangible investments; basic and applied knowledge; external communication; diffusion; and innovation. For materialising such eight NIS dimensions 29 individual indicators were selected for a total of 69 countries. These countries range from the most developed and largest economies in the world, through the emerging economies, to the less advanced developing countries. For each of the 8 relevant NIS dimensions between 2 and 6 of these 29 indicators were allocated. The definition of the NIS dimensions and the selection of indicators tried to respect theoretical and logic criteria of organization of the data.

Overall the data basis that was developed and the methodological steps that were taken represent a unique attempt to cover such a large and diverse number of countries with the aim of analysing their behaviour in terms of creating, consolidating and advancing their national innovation systems. As it will be shown, the resulting outcomes of this paper have empirical, theoretical and normative potential.

Following this introduction the paper is divided into five main sections. Section 2 presents the conceptual context of the mapping and taxonomisation exercise that will be carried out. In section 3 the method followed is described, with information about the observed NIS dimensions, about the variables aggregated into each of those dimensions and about the economies that were selected as well. Next section 4 presents the results of the empirical analysis, by concentrating first on the mapping of the individual NISs and then on the structure that stems from a cluster analysis. The clusters that emerged are observed in section 5, providing an interpretation for the contrasting positions of the different countries involved in this exercise. Finally, the concluding section attempts at a generalization based on the analyses of the previous sections, suggesting a possible taxonomy of national innovation systems.

## **2. The NIS perspective**

The NIS concept has been used as a “focusing device” in bringing forward the interdependent and distributed features of innovation. The concept was developed in the 1980s and has since had a very significant impact, both in innovation studies and in policy arenas.

This section explores the NIS concept by analysing its evolution since the 1980s. The understanding that emerged in the innovation literature is discussed, and the barriers that still restrain its translation into quantitative analyses are considered. Finally, the adequacy of using it in the context of less developed economies is discussed, namely taking into consideration the profusion of recent work in this perspective in many developing countries.

### **2.1 The qualitative dimensions of innovation**

In the economics of technical change the acknowledgement of the systemic nature of the innovation process represents a key claim in favour of considering the interactive and historical nature of the innovation phenomenon. Such claim however embodies a methodological option. The systems approach assumes that the appreciation of the evolution of countries’ technological capabilities and performances makes these quite complex objects of analysis, one cannot understand the picture without the detail. Consequently, this stands in contrast with traditional growth accounts, which take statistical aggregates as the privileged source of empirical information. The NIS approach follows an alternative path, the awareness of concrete institutions and varieties in macroeconomic environments are at the centre stage.

This NIS concept was initially put forward as a qualitative concept for describing the technological, economic, social and institutional dimensions of innovation in advanced economies. Freeman (1987) deployed it in his discussion of the Japanese innovation system, while Lundvall (1985, 1992) and others firstly applied it in connection to the empirical observation of the interactions and institutional framework that support innovative activities in the Scandinavian economies. From these initial applications, the concept was rapidly generalised to all the most advanced economies, being Nelson’s 1993 book a good example of this.

In spite of a relative variation in the definition of NIS (see Niosi, 2002) the major contributions are convergent in highlighting the interactions between firms and institutions as well as noting the path-dependent character of those relations. Further, that variation can even be justified for ontological reasons: the historic nature of the object does not allow for a single definition of innovation system. As claimed by Lundvall (2004) “to develop ‘a general theory’ of innovation systems that abstracts from time and space would therefore undermine the utility of the concept both as an analytical tool and as a policy tool”.

Assuming that variation on the understanding of ‘innovation system’, the approach has developed significantly since its inception, and several associated concepts have emerged stressing different aspects of the innovation systems dynamics. Some of these derived concepts refer to sub-national realities, such as in the work of Saxenian (1994) that dealt with the local conditions in Massachusetts’ Route 128 or in Silicon Valley, or in the work of Cooke (1998), Braczyk (1998), Landabaso (1995) or Asheim and Gertler (2004) that refer to “regional innovation systems” in the European context. In contrast,

other approaches that derive from the initial NIS concept refer to realities which are supra-national or that simply are not geographical in their nature. That is the case of the “sectoral systems of innovation” approach (Breschi and Malerba 1997, Malerba 2004), that stresses the opportunity and appropriability conditions in different sectors as key factors in determining specific cumulativeness paths, or also the case of the “technological innovation systems” approach (Carlsson et al. 1995 and 1997) that focuses on generic technologies with general application over many industries.

All these developments of the original concept can be seen as evidence that research on innovation has tried to capture the manifold dimensions of innovative phenomena. However, in this paper our interest is not on how each of those derived concepts developed and acquired its own place in the innovation literature. Rather we are interested in the original concept and our analysis is centred on the national level, with the objective of promoting a cartography of NISs development and characteristics.

In doing this we have to pay attention to the fact that the NIS concept was initially put forward as a qualitative construction. It came somewhat before in time than many of the most recent technological developments, but it is clear that it was already put forward in connection to the central characteristics of the present competitive regime. It was not by chance that the concept emerged in the late 1980s when the signs of a new techno-economic paradigm were already clear, with a set of radically new technologies starting to diffuse economy-wide (Freeman and Perez 1988, Freeman and Soete 1997). A key feature that has differentiated the new paradigm from the previous ones is precisely the permanence and ubiquity of innovation, which evolved from a relatively discrete and limited occurrence to a much more pervasive aspect of economic life. In the new paradigm firms must be involved, more than ever, in continuous innovation to remain competitive. In this process firms allocate a greater share of their resources to the internal production and combination of knowledge and to the external tapping of other sources, including the research organizations and their competitors (Autio et al. 1995). National governments have also been part of this process, by strengthening the S&T infrastructure (Teubal et al. 1996, Rush et al. 1996) and by trying to improve the regulatory framework and more generally the institutional conditions affecting innovation. These developments have led to what many have classified as the “knowledge based economy” (OECD 2000) or, in a relatively more dynamic interpretation, to the “learning economy” (Lundvall and Borràs 1999, Gregersen and Johnson 2001).

Summing up, innovation is central to understanding the competitive dynamics in contemporary economies. It emerges from new combinations of knowledge and depends on the institutional arrangements prevailing in each society, making it an essentially qualitative process.

## **2.2 How far can we go in the quantitative analyses of NISs?**

It is that qualitative nature of innovation that defies quantification. At least two recent developments can be considered as weakening the barriers to a possible quantification. Firstly, we might refer to the emergence and wide use of several new innovation indicators and sources. As it is known significant advancements have been made in the field of innovation measurement recently, through the implementation of a variety of new indicators. This has happened since the early 1990s when a new generation of innovation indicators has been established, adding to the classical “input” and “output”

indicators. A significant part of this new generation of indicators stems from the process associated with the publication of the “Oslo Manual” (OECD 1992, Smith 1992) and to the subsequent setting up of several innovation surveys, being the most prominent the three CIS inquiries implemented by EUROSTAT in collaboration with several national statistical offices. From the studies that have been produced with these CIS-based indicators, it is clear that several dimensions of the innovation process which could not be previously studied can now be approached and understood by using quantitative data and analysis (Smith 2004, Evangelista et al. 1998). Another component of this new generation of indicators is more recent yet, and relates to the establishing by the OECD, the EU and other international organizations of statistics trying to reflect the diffusion of ICTs and other related technologies. Besides this new generation the most recent period has also witnessed to the creation and intense use, by both the academic and the policy-making communities, of several other indicators built up from the more “classic” bibliometric, patent, trademark and R&D statistics (Mendonça, Pereira and Godinho 2004).

The second recent development that can be seen as favouring the type of exercise we will be undertaking in the following sections relates to a demand-side effect. Policy-makers have been asking their advisers and researchers too for supplying them with summary measures of their countries’ and regions’ relative innovation status. This is part of a more general benchmarking movement, and in the area of innovation the most notable result has been the production of “innovation scoreboards”.<sup>1</sup> This type of exercise has been criticized for tending to reduce the multidimensionality of innovation processes to just one simple summary measure. Such scoreboards «can provide useful information for macro level policies [...], but a scoreboard is of less value as one moves to the meso and micro level, where firms are active and where most policy actions occur» (Arundel 2001). From this and other similar criticisms that have been put forward we can conclude that while the summarizing need remains, excessive simplification shall be avoided in the finding of solutions.

### **2.3. The NIS concept within the developing countries context**

As pointed out above, the NIS concept emerged in the late 1980s and in the 1990s in the context of research focusing on more advanced economies. More recently however this concept has been applied more widely to the developing and intermediate economies with several studies emerging focusing on different countries in Asia (China, e.g. Gu, 1997; India, e.g. Krishnan, 2003; Thailand, e.g. Intarakumnerd, 2004; or Vietnam, e.g. Sinh, 2004) and Latin America (Brazil, e.g. Cassiolato *et al.*, 2003; Mexico, e.g. Cimoli, 2003).

In a sense this new trend may be interpreted as a return to the origins. In the light of pioneering material by Chris Freeman (2004) originally written in the early eighties but only recently made available, the concept of national innovation system arose from the analysis of the historical factors behind the stunning economic development of countries like Germany and Japan that were well behind the technological frontier in the late 19th and early 20th centuries. As Lundvall (2004) notes in his introduction to Freeman’s paper, the Listian emphasis on governmental initiatives to build a technological infrastructure as well as the importance attributed to the coupling between knowledge

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<sup>1</sup> In 2000 the EU Lisbon summit decided to develop a European Innovation Scoreboard, which is an example of this approach.

institutions and firms represents the hallmark of modern research on innovation systems,

This recent recovery of the NIS concept in the context of the analysis of economic development raises however the methodological problem of knowing whether what was learnt in the study of more advanced NISs is relevant for all sorts of economies regardless the maturity of their actual innovation systems. Such question is particularly relevant for countries in lower and intermediate levels of development seeking to progress to more advanced stages of economic development based upon the promotion of endogenous innovation. Through the technique that will be presented in the next section, we can experimentally test the validity of applying the NIS concept to those economies.

### **3. The method for mapping NISs**

The technique we will deploy now is partially based on previous work of Godinho et al. (2003). In that paper an exploratory exercise aiming at mapping different NISs was put forward. Although simple in the steps it required to generate graphical representations and quantitative indicators for each NIS that exercise showed that the method proposed offered some interesting possibilities. The cartography generated by it allowed the direct comparison of countries by visualizing in bi-dimensional space the graphic pattern of the relevant dimensions of their respective NISs. In this way a comparative analysis of weaker and stronger dimensions of each NIS was made possible. Further, as it was shown this analysis could fruitfully be applied to both the more and the less advanced economies. Now we will extend that approach to a much larger number of countries, 69 on the total, and in connection with this a set of 29 indicators will be processed. The objective is moving on from an initial essentially exploratory stage to a more robust work in terms of data collection, processing and analysis. This analytical quest has practical importance for drawing normative implications, namely by illuminating the cognitive and institutional factors that are more relevant for the economies aiming at catching up. As stated above, the purpose of the analysis now is to identify what are the common and differentiating factors of different types of NISs in order to propose a taxonomy of innovation systems.

Next we will briefly describe in 3.1 the proposed technique and how it is based on the decomposition of an innovation system in terms of a set of major dimensions. In subsection 3.2 we will present the indicators that were selected to represent each of those major dimensions.

#### **3.1. The NIS “dimensions” and the variables involved in the exercise**

The “National Innovation System” concept is a complex model that grew out of the 1970s and 1980s innovation theory advancements that occurred as a reaction to the archaic “linear model”. This means that many of the analytical perspectives stemming from previous models of innovation, from the interactive vision of S&T-push and demand-pull factors (Freeman 1979) to the chain-link perspective of innovation (Kline and Rosenberg 1986) are now in practice part of the broader NIS theoretical framework. However, the NIS model goes much further than these previous approaches, since it concentrates not just on a few actors and local processes that lead to the emergence of single innovations, but it proposes a much wider view of a system with a large diversity actors, institutions and interactive arrangements that push forward structural change in the economies and societies.

This complex perspective enclosed in the NIS concept is at odds with many simplifying graphical representations of the national innovation system that have emerged. Those representations, by focusing just on the different types of actors and the possible connections between them, overlook a multiplicity of other aspects that are enclosed in the NIS theorisation.

The technique we are now employing will also generate a graphical representation of NISs, but of a different sort. We will focus on four groups of aspects in the way to mapping and measuring the overall performance of NISs. Those groups are as follows:

- (i) *preconditions for innovation;*
- (ii) *inputs into the system;*
- (iii) *structural organization;*
- (iv) *system outputs.*

In what follows we will elaborate on each of these groups, discussing the NIS dimensions associated with each of them and presenting (in small boxes) the indicators we consider most appropriate to stand for each dimension. In reading what comes below one must be aware that these NIS dimensions necessarily emerge, in practice, as a compromise between innovation systems theory and the indicators which may be gathered to stand for the different dimensions that underlie the concept of “innovation system”.

#### (i) Preconditions for innovation

We will consider two sorts of innovation preconditions: first *market conditions* and next *institutional conditions*.

In principle, for producers of tradable goods the global market represents their potential demand. But one knows that transaction costs and innumerable other frictions, related to geographical distance, transport costs or the availability of adequate distribution channels, limit a perfect access to global markets. So, and given the national logic of transportation networks, the easiness of business contacts in national language, etc., the national market still remains in many cases as the most important stimulus for individual firms. One can therefore admit that the larger this national market is, in terms of overall extension, affluence and sophistication, the greater will be the market opportunities for firms to produce and innovate. This is certainly valid mostly for non-tradable products firms, as it is the case of many service industries, but also for many of those firms producing tradable products.

Also important in this view of market and demand conditions is the way consumers are spread in the national space. A territory with low population density will be much more difficult to serve than one where the population is more densely distributed.

#### **Dimension 1 - “Market conditions”**

- Income per capita
- Overall GDP size
- Population density

A second group of preconditions relates to “institutions”. As stressed above, this is a fundamental insight of innovation systems theory: the historic evolution of social and

economic spaces shapes their institutions; these are relatively stable in time and modify slowly; and the way economic agents behave depends largely on them. But, given their nature, institutions are very difficult to represent by any sort of quantitative indicator. We tried to deal with this by considering three sorts of indicators. Firstly, we took an indicator of income distribution. The assumption is that a more even distribution of income improves the capacity of larger segments of the demand to buy new products. Further, lower values of such indicator might indicate higher levels of political stability and social cohesion, which might be good for innovation to happen. Secondly, we selected an indicator that combines the youth of the population with life expectancy. The former indicates possible adaptability and flexibility in the social fabric, while the latter indicates whether healthy conditions exist for both workers and consumers. Finally, we selected a corruption index as an indicator of possible social and economic (in)effectiveness.

**Dimension 2 - “Institutional conditions”**

- GINI index
- Youth of population
- Life expectancy
- Corruption index

(ii) Inputs into the system

A good supply of inputs is also a precondition for systems functioning well. So, in connection with the contextual factors highlighted above, we will now consider other two sorts of preconditions: “*intangible and intangible investment*” and “*knowledge*”. The first of these factors might be seen as a primary input and the second as an intermediary input (and therefore as an output of the system on its own right) of the innovation system.

We will take three indicators for intangible investment: education expenditures, R&D investment and investment in physical capital. All these indicators are well known but they perform specific functions in our framework. Education expenditures stand for the efforts in preparing younger generations for the future. Such efforts do not have an immediate impact on innovation, though their intensity provides a sign to innovators that society has a more or less strong commitment in relation to basic knowledge accumulation. The same happens with GERD, even though in relation to this indicator the impacts on innovation clearly happen in a more short-medium-term horizon. In the sense they help promoting general and basic knowledge, both education and R&D investments have a direct impact on the dimension we will be discussing next (*knowledge*). Finally, the overall investment rate in physical capital has yet a more short term impact, facilitating the penetration of innovation through the acquisition of capital goods embodying new technology. This last aspect relates yet with another dimension we will be discussing below (*innovation diffusion*).

**Dimension 3 - “Intangible and tangible investment”**

- Education expenditures as a percentage of GDP
- Education expenditures per capita
- GERD as a percentage of GDP
- GERD per capita
- Investment rate (GFCF as a percentage of GDP)

“*Knowledge*”, like “*institutions*”, is another dimension that resists to quantification. However it is such a critical dimension of a NIS that we can not avoid dealing with it. Three knowledge levels might be considered: general knowledge, of the type that is acquired through participation in the education system; scientific knowledge; and technologic knowledge. For the first level an indicator of educational attainment was selected. For the other two levels, three indicators were envisaged: scientific publication; number of researchers in the labour force; and tertiary enrolments in S&T subjects. The first indicates the country’s scientific output and provides information of a possible longer term innovation potential. The second, the number of personnel involved in research activities, is correlated to a previous indicator (GERD/GDP), but it is used here in connection with both scientific and technologic knowledge. The last indicator was selected given the difficulty found in identifying an appropriate measure for technologic knowledge. But, in line with what is argued in Fagerberg & Godinho (2004), we admit that the higher the proportion of tertiary students enrolled in technical subjects the stronger the society orientation towards values and behaviours that favour a dynamic technology base.

**Dimension 4 - “Knowledge”**

- Population with 2+3 Education as a percentage of total population
- Researchers as a percentage of labour force
- Scientific papers per Capita
- Tertiary enrolment in technical subjects as a percentage of the population

(iii) Structural organization

The structural analysis of economies tends to concentrate on the distribution of value added and employment among different sectors. Also the analysis of countries’ competitiveness tends to emphasize the specialization composition in terms of the sectoral origin of exports. Further industrial organization analysis focus on yet another structural aspect, the degree of industry concentration, normally analysed in connection to firm size distribution. All these structural levels are the outcome of dynamic competition processes driven mainly by innovation and technological change.

It has been known for long now that the sectoral characteristics of an economy affect the direction, nature and intensity of innovation (Pavitt 1984). To understand well an innovation system behaviour it is pertinent to have information about how the economic activity (production, exports) is distributed among sectors with different R&D and knowledge intensities. In connection to this, and in conformity with the structural levels highlighted in the previous paragraph, one also needs to have information about the size distribution of firms in the economy. This is a sort of information that is very difficult to find for a multi-country sample like ours given the diversity of classification practices that statistical offices follow in relation to firm size. As a proxy we took the sales of the home-based top global 500 R&D-performing companies as a percentage of GDP. Empirical research has stressed the role of this sort of large multinational firms in generating a greater share of global innovative activities (Pavitt and Patel 1988, Patel 1995, Zanfei 2000). Despite the increasing internationalisation of R&D that has gone along the activities of these companies (Meyer-Krahmer et al. 1998) the fact is that they still are the backbone of a great deal of the domestic innovative activities in the countries where they come from.



**Dimension 5 - “Economic structure”**

- Value Added in High-Tech & Medium High-Tech Activities (%)
- High-Tech & Medium High-Tech Exports (%)
- Sales of home-based top 500 global R&D companies / GDP

A second structural aspect that deserves attention when considering the organization of a NIS has to do with the discussion of the frontiers of each national innovation system and the way it relates outside the national space. It has been discussed whether in an era of globalisation the national level of analysis retains the same relevance it had before. As pointed out above, several arguments (transaction costs in international trade, common infrastructure and culture, national policies...) show that the national level is still relevant for economic and innovation analysis. But, despite that, it is also acknowledged that external communication is essential for the vitality of the innovation system. Such communication is a way of increasing the diversity of stimuli into the innovation system and for bringing in key information and knowledge that lack internally. A good connection to the outside world is therefore essential as a complement to the knowledge generated domestically. The three indicators we propose below provide an adequate account of this dimension.

**Dimension 6 - “External communication”**

- (Exports + Imports) / GDP
- (Inward + Outward stocks of FDI) / GDP
- Bandwidth in international connections (bits per Capita)

**(iv) System Outputs**

The major outputs of a NIS have naturally to do with the system’s innovation performance but also with “*diffusion*”, i.e. with the circulation and spreading of knowledge and new technologies among the different parts of the system. A major theoretical point that the NIS approach brought to the analysis of the innovation process has precisely to do with this redistributive power of the innovation system (David and Foray 1995). Such power is a direct function of the collaborative arrangements and relatively stable linkages that firms set up with a diversity of actors, ranging from their suppliers (including finance providers), clients and competitors, to the R&D and intermediate organizations that produce and transfer S&T knowledge to the economy. In the absence of indicators that might provide an account of these interactive patterns in the NIS, we have to rely on more classic indicators of the diffusion of specific innovations. These indicators have however their own merits. The first three are combined into an aggregate indicator of ICT diffusion. The fourth refers to a consumer product technology. The fifth has not been much used, but it seems pertinent since indicates the diffusion of a specific type of innovative practice within the different economies.

**Dimension 7 - “Diffusion”**

- Personal Computers per capita
- Internet Hosts per capita
- Internet Users per capita
- Cellular Phones per capita
- ISO 9000 + ISO 14000 Certificates per capita

Finally, we focus on the eight critical dimension to account for NISs dynamics: “*innovation*”. The behaviour on this dimension results from the contextual conditions, the resources mobilized and the overall organization of the system. We take here two different indicators for innovation: patenting and trademark activity. The first is a well established innovation indicator. It provides information about the sort of innovation that derives and relates basically to technologic knowledge. The advantages and disadvantages of this indicator are well known. We can admit that the total number of patents granted to each country is a good indicator of innovation propensity and potential performance.

The second indicator, trademark activity, has been recently argued for as an innovation indicator (Mendonça et al. 2004). The idea is that this indicator provides information on the marketing efforts that firms carry out to establish new and differentiated products in the marketplace. The flow of new trademarks (as the flow of new patents) might therefore be understood as an indicator of innovative efforts, in connection to the approach of firms to the demand they are facing.

**Dimension 8 - “*Innovation*”**

- US Patents per Capita
- Trademarks per Capita

### 3.2. Data sources and the process for estimating the basic NIS dimensions

Having defined the eight basic dimensions of the national innovation system, we will now describe briefly the data sources, clarify the construction of the indicators and how they are aggregated into the different dimensions.

Table 1 below identifies the indicators that were kept as representing better each of those dimensions and provides information about the sources and other details related to each indicator. The sources of the data we are using are in almost all cases national and international statistical and regulatory agencies. We sought to retain a diversity of indicators, based on different types of variables (stock and flows, monetary and physical) in order to provide appropriate information about the eight NIS dimensions. We are aware that many of the selected indicators do not constitute optimal solutions for portraying the different dimensions of a NIS. As stated above the selected indicators are a compromise between innovation systems theory and available statistical data. Thus we had to act pragmatically, choosing the indicators according to their accessibility, reliability and adequate coverage of the period to be observed. Fortunately the quantity of data we have now available has no comparison to what existed only 10 or 15 years ago. The Internet has played a fundamental role, making many international statistics readily available on-line. Moreover, some large databases have also been made accessible through other electronic supports such as CD-ROMs.

All together we are using 29 variables for 69 countries.<sup>2</sup> The period to which the data refers to is normally the years after 2000, with many variables referring to 2002 or 2003, even tough a few exceptions exist (for details see table below).

<sup>2</sup> Amable et al. (1997) proposed an exercise with some aspects in common with the one we are undertaking now. Their analysis involved a larger number of indicators, even tough for a much smaller sample (only 12 countries, all of them belonging to the OECD).

**Table 1**  
**Variables and Indicators used to determine each NIS dimension**

Code	Variable/indicator name (V1-V30) NIS Dimensions (D1-D8)	Source	Year	Construction of the Indicator
D1	Market Conditions			
V1 V2 V3	Gross Income per Capita PPP(US\$) Population Density per square km GDP (Millions of Dollars)	1/2/11/12 2/3 2/4/5/12	2001/2003 2001/2003 2000/2001/2002	LOG LOG
D2	Institutional Conditions			
V4 V5 V6 V7	Gini Index Youth of the Population (Population Under 15 y.o.) Life Expectancy at Birth Corruption Index	5/13/14 1/5 5/10 6	1992-2000 2002 2002 2003	Inverse (1/Gini Index) % of Total Population (Male + Female) / 2 Score between 0-10
	Notes: V5+V6 aggregated into a single indicator; In the Corruption Index 10 is given to the less corrupt countries			
D3	Investment Climate			
V8 V9 V10 V11 V12	Education Expenditures % of GDP Education Expenditures per Capita GERD % of GDP GERD per Capita Investment Rate % of GDP	7/8/15 3/7/8/15 5/8/14 3/5/8/14 2/9/4	95-97/2001/2002 95-97/2001/2002 2000/2001/2002 2000/2001/2002 2001/2002	Per Capita, LOG  Per Capita, LOG
	Note: V8+V9 aggregated into a single indicator; V10+V11 aggregated into a single indicator			
D4	Scientific Knowledge			
V13 V14 V15 V16	Population with 2+3 Education % of Total Population Researchers per Capita (per Million Inhabitants) Scientific Papers per Capita (per Million Inhabitants) Tertiary Enrolment in Technical Subjects per Capita	8/14 8/5/7/14/16/17 18 19	2001/2002 1990-2000/2001/2002 1998 (a) 1998 (a)	2+3 / POP
	(a) or latest available year.			
D5	Economic Structure			
V17 V18 V19	Value Added in High-Tech & Medium H. –T. Activities (%) High-Tech & Medium High-Tech Exports (%) Sales of home-based Top global 500 R&D Companies/GDP	19 19 20/2	2000 (b) 2000 (b) 2001	(c) (d) (e)
	Notes: (b) or latest available year; or latest available year; (c) For Hong Kong – values of 1998 and for D.R. of Congo – values of 1990; (d) Share of medium and high-tech activities in Manufacturing Value-Added* share of Manufacturing Value-Added in GDP; (e) Sum of the worldwide sales of the home-based companies that are part of the ranking of the top 500 global R&D performers as a percentage of the GDP of corresponding country.			
D6	Openness & Absorption			
V20 V21 V22	(Exports + Imports) / GDP (Inward + Outward stock of FDI) / GDP Bandwidth (bits per Capita)	5/14/27 21/14 3/22	2002 2002 2002	X+M Inward+Outward

(Table continues next page)

Table 1. (continuation from previous page)

Code	Variable/indicator name (V1-V30) NIS Dimensions (D1-D8)	Source	Year	Construction of the Indicator
D7	Diffusion			
V23	Personal Computers per 100 inhabitants	3	2003	ISO 9000+14000/POP
V24	Internet Hosts per 10000 inhabitants	3	2003	
V25	Internet Users per 10000 inhabitants	3	2003	
V26	Cellular Phones per 100 inhabitants	3	2003	
V27	(ISO 9000 + ISO 14000 Certificates) / Population	23/3	2002	
	Note: V23+V24+V25 aggregated into a single indicator			
D8	Innovation			
V28	US Patents per Capita	24/25	2003 (f)	% of Total POP, LOG
V29	Trademarks per Capita	26	2003	% of Total POP, LOG
	Note: (f) For countries with a very few patents an yearly average was calculated, normally between 1997 and 2003.			
	Other Variables (Auxiliary)			
V30	Population 2000 (Millions)	3	2003	
<b>Sources:</b> 1. IMD, World Competitiveness Yearbook 2004 2. World Bank, World Development Report 2003 3. ITU, World Telecommunication Development Report 2003 4. Taiwan Statistical Data Book 2001, Council for Economic Planning and Development, Republic of China 5. UNPD, United Nations Development Program Report 2004 6. Transparency International Corruption Perception Index 2003 7. World Bank, World Development Report 2002 8. UNESCO, Institute for Statistics 9. EIS, European Innovation Scoreboard 2003  10. <a href="http://www.indexmundi.com/taiwan/life_expectancy_at_birth.html">www.indexmundi.com/taiwan/life_expectancy_at_birth.html</a> 11. <a href="http://www.nu.hu">www.nu.hu</a> 12. <a href="http://www.worldlanguage.com">www.worldlanguage.com</a> 13. <a href="http://www.phrasebase.com">www.phrasebase.com</a> 14. <a href="http://www.nationmaster.com">www.nationmaster.com</a> 15. <a href="http://www.business.nsw.gov.au">www.business.nsw.gov.au</a> 16. <a href="http://www.serenate.org">www.serenate.org</a> 17. <a href="http://www.cepd.gov.tw">www.cepd.gov.tw</a>  18. <a href="http://www.nsf.gov">http://www.nsf.gov</a> - Science and Engineering Indicators–2002 19. UNIDO Scoreboard Database, Industrial Development Report – 2002/2003 20. DTI - <a href="http://www.innovation.gov.uk/projects/rd_scoreboard/database/databasefr.htm">http://www.innovation.gov.uk/projects/rd_scoreboard/database/databasefr.htm</a> 21. UNCTAD, United Nations of Trade and Development 22. <a href="http://www.uneca.org">www.uneca.org</a> 23. The ISO Survey of ISO 9000 & ISO 14000 Certificates 24. OECD Patent Database, July 2003 25. US Patent and Trademark Office, March 2004 26. OHIM, Office for Harmonization in the Internal Market 27. <a href="http://www.mof.gov.tw">www.mof.gov.tw</a>				

The 29 relevant variables/indicators listed above were transformed using a standardization procedure. The next step was the aggregation of the variables into each dimension. Similar weights were used for all the variables, with the exceptions noted in table 1 above, of two or three single indicators being aggregated into another indicator. In these cases the aggregated outcome counted as just one indicator. Overall 24 resulting indicators were aggregated into the NIS dimensions generating eight composite indicators.

We must clarify that in general each variable/indicator covered all the 69 countries in the sample, even though in a very few cases the data base that was built presented missing values. In those cases the composite measure of each NIS dimension was calculated for the country whose data was missing on the basis of only  $n-1$  (or  $n-m$ , more generally) indicators.

In what regards country selection we tried to gather information covering both the advanced economies (large and small) and the catching up and developing economies. All the OECD economies were included, plus the EU members and candidate countries. All the Asian “tigers” were included, even though not all of them are properly “nations”. For the rest, the criterion was that the selected countries should have at least 20 million inhabitants. In this way we could assure that the analysis covered a great part of the world population. On the whole these countries stand for approximately 87.4% of the world population.

Having gathered, processed, summarised and critically observed all the necessary information, we were able to represent the results for each dimension along eight axes, using the so-called radar-type charts. We will present in subsection 4.2 below the graphical results of the exercise.

#### **4. Data analysis**

This section starts with a presentation of a cluster analysis done on the eight NIS dimensions for the 69 countries in the sample. Next those dimensions will be displayed graphically for the different NISs in accordance to the cluster structure deriving from the previous cluster analysis.

##### **4.1. Cluster analysis**

In the sequence of having mapped the National Innovation Systems of a sample of 69 of the world’s largest and most innovative economies, we will now proceed with a cluster analysis. The objective is to suggest a taxonomy of National Innovation Systems.

As it is known, cluster analysis allows for the identification of homogeneous groups of cases in a given sample, through the simultaneous minimization of within-group variation and maximization of between-group variation. Hierarchical clustering was the procedure adopted to divide our sample into homogenous groupings. This procedure starts by combining the two most similar cases into a cluster and proceeds by repeating this step up to forming just one cluster. In this process one has to decide where to stop, by defining what is the desired final number of clusters. Three alternative methods for linking the different cases were followed: between groups linkages; within groups linkages; and Ward’s method. Further three distance measures (Euclidean distance, squared Euclidean distance and block distance) were used for each of those alternative methods. All together nine clustering algorithms were therefore adopted for forming

clusters. This work was necessary because different methods of cluster analysis may generate quite different results. By comparing the outcomes of running the different algorithms, one can assess how robust might be the cluster typology obtained. These nine clustering algorithms were run by using as inputs the eight axes of the NISs that were drawn from our dataset as explained above.

For each of those nine runs we analyzed the cases of 2, 5 and 9 clusters. These numbers are not arbitrary. They stem from the observation of both the ‘agglomeration schedules’ and the ‘dendograms’ proceeding from the statistical analyses.<sup>3</sup> The visual observation of the dendogram allows one to infer when to stop the exercise of clustering. This shall happen when the distance between the new formed clusters and the existing ones increases significantly. The same inference might be made more precisely through the analysis of the similarity coefficient in the agglomeration schedule. In our case, the highest drop in the similarity coefficient happened, for most of the 9 runs, when two large “megaclusters” arose. However important drops in that coefficient also happened in most of the runs when reaching 5 and 9 clusters respectively.<sup>4</sup> We will therefore report next according to this 3-level structure (2, 5 and 9 clusters).

### **Cluster Analysis – Level 1**

In all the nine runs that were carried out two large ‘megaclusters’ emerge (M1 and M2). Each of them is composed respectively of about one-third and two-thirds of the countries in the sample. We will call the first of these two groupings the ‘developed NISs’ (M1) and the other ‘the developing NISs’ (M2).

The very important drop in the similarity coefficient that happened when this stage of cluster analysis was reached means that: (i) two quite distinct groups of NISs exist; while simultaneously (ii) each of them sharing a high degree of internal cohesion. This allows one to infer that a significant divide separates the two major NIS types. Further it suggests that an important qualitative and quantitative change might be needed in order to jump the gap that separates M2 from M1.

By looking at the 9 runs of the cluster analysis that were performed, one concludes that those two groups are relatively stable, with almost all of their respective members remaining attached to each one of them all over the process (see table 2). However, some marginal ‘noise’ arises, with a few countries moving between megaclusters or eventually resisting integration in any of them. The most notorious case arises with Hong Kong, that in 3 out of the 9 runs is not ‘attracted’ into any of the larger groupings, while in the remaining six runs it is absorbed in equal proportions by M1 or M2. A similar but less extensive situation arises with Luxembourg that in 2 out of the 9 runs

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<sup>3</sup> The ‘dendogram’ is a tree diagram that represents the sequence of mergers of cases into clusters and, from a certain step on, between already existing clusters. It allows one to identify the clusters that are formed in the successive steps, their membership as well as how relatively far (‘different’) are the new larger groupings from the pre-existing clusters or cases from which they stem from. The ‘agglomeration schedule’ provides information about the evolution of the proximity coefficient along the successive steps of the cluster analysis. When using distance measures, low drops in the proximity coefficient mean that the new cases being merged are rather alike, while big jumps indicate that the new mergers are rather dissimilar from the previous ones. One has to stop the clustering process when the greatest increase in the distance occurs between two successive steps (i.e. when the highest drop in the similarity coefficient happens).

<sup>4</sup> Detailed statistical outputs can be provided on request.

moves from M1 to M2. What happens with these two economies is not surprising, probably stemming from an idiosyncratic nature of their respective NISs. Finally, an interesting situation happens in 1 out of the 9 runs, when a group of 5 countries (Czech Republic, Hungary, Malta, Portugal and Slovenia) moves from M2 to M1. This might be seen as evidence that these countries are attempting to cross over the wide gap identified above and that they will eventually catch up into a ‘developed NISs’ status in a not so distant future.

**Table 2**  
**Megaclusters 1 and 2**

<b>M1 - Developed NISs</b>	<b>M2 - Developing NISs</b>
<i>‘Permanent members’:</i> Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Ireland, Japan, Korea (republic of), Netherlands, New Zealand, Norway, Singapore, Spain, Switzerland, Sweden, Taiwan, United Kingdom, United States	<i>‘Permanent members’:</i> Algeria , Argentina, Bangladesh, Brazil, Bulgaria, Chile, China, Colombia, Congo (D. R.), Cyprus, Egypt, Estonia, Ethiopia, Greece, India, Kenya, Indonesia, Iran (I. R.), Latvia, Lithuania, Malaysia, Mexico, Morocco, Myanmar, Nigeria, Peru, Philippines, Poland, Russia, South Africa, Slovak R., Sudan, Tanzania, Ukraine, Pakistan, Romania, Thailand, Turkey, Venezuela, Viet Nam
<i>‘Non-permanent member’:</i> Luxembourg →	<i>‘Non-permanent members’:</i> ← Hungary, Czech Republic, Slovenia, Malta and Portugal
← Hong Kong →	

### Cluster Analysis – Level 2

When one moves to a five cluster partition, the stability of the results decreases in relation to the previous situation. This affects mainly the developed NISs megacluster that despite having a smaller membership reveals a larger internal variation. In contrast, the developing NIS megacluster shows greater consistency in the way it is divided into different clusters and in the stability of their respective memberships. As a consequence in 7 out of 9 runs, two clusters emerge within the developing NIS megacluster. One of these clusters stays almost unchanged even in the remaining 2 runs, when megacluster 2 is divided into three clusters. That cluster, which we might call ‘unformed NISs’, is comprised of 12 or 13 countries, 8 of them from Africa, 3-4 from Asia and one from Latin America. In relation to the remaining countries of megacluster 2, which by now we will call ‘structuring NISs’, they tend to cluster in one grouping, but in 3 of the runs it breaks down into two smaller groupings<sup>5</sup> (see table 3).

**Table 3**  
**A partition of the Developing NIS megacluster**

<b>Unformed NISs</b>	<b>Structuring NISs</b>
<i>‘Permanent members’:</i> Algeria, Bangladesh, Colombia, Congo (D. R.), Ethiopia, Iran (I. R.), Kenya,	<i>‘Permanent members’:</i> Argentina, Brazil, Bulgaria, China, India, Indonesia, Mexico, Peru, Philippines,

<sup>5</sup> This happens when using Ward’s method for linking the different cases.

Sudan, Myanmar, Nigeria, Tanzania, Viet Nam	Russia, South Africa, Slovak R., Ukraine, Romania, Thailand, Turkey, Venezuela
<i>'Non-permanent member':</i> Pakistan (this country upgrades out of this group in 2 runs)	<i>'Non-permanent members':</i> Hungary, Chile, Czech Republic, Cyprus, Egypt, Estonia, Greece, Latvia, Lithuania, Malaysia, Malaysia, Malta, Poland, Portugal, Slovenia (most of these countries move out of the above group in 2 or 3 runs, forming a third autonomous cluster, in one run 5 of them upgrade to megacluster 1)

As stated above, the 'developed NISs' megacluster shows a larger variation when moving to a thinner definition of clusters. The most frequent situation, however, is to have 3 groupings, one containing just one NIS (Hong Kong), a second one clustering together three small European economies (Belgium, Denmark and Luxembourg), and a third one that reunites most of the countries in Megacluster 1. We will report further on the divisions within megacluster 1 below, when analyzing the results for the 9 clusters partition.

### Cluster Analysis – Level 3

As hinted above, in general the Developing NISs megacluster is much more homogeneous than the Developed NIS megacluster. As a matter of fact, even when proceeding to the 9 clusters partition level, the overall lines of division that were found for megacluster 2 in the former level of analysis stay relatively unchanged. In 3 out of the 9 runs of the cluster analysis, however, M2 breaks down into a larger number of smaller groupings. As these smaller groupings are clearly visible at thinner levels of analysis, when 10 or more clusters are retained for the whole sample, it makes sense to report on their membership.

Table 4 shows the 3 major groups of NISs that emerge within the Developing NISs megacluster (G1, G2, G3) and the subgroups that emerge out of G2 (G2a, G2b, G2c). The 3 major groups were classified as 'Unformed NISs', 'Emerging NISs' and 'Catching up NISs', names which correspond to their status and general characteristics in terms of NIS maturity. It is interesting to notice how all the emerging economies proper cluster within G2b. When comparing with NISs of economies with similar economic development levels, these G2b NISs have in common the fact that they are doing relatively better in innovation than in diffusion. This may suggest that a scale effect may operate, leading these economies to perform relatively better in terms of innovation.

**Table 4**  
**Further partition of the Developing NIS megacluster**

<b>G1 - Unformed NISs</b>	<b>Structuring NISs</b>	
	<b>G2 - Emerging NISs</b>	<b>G3 - Catching Up NISs</b>
<i>'Permanent members':</i> Algeria, Bangladesh, Congo (D. R.), Ethiopia,	<i>'Permanent members':</i> Argentina, Brazil, Bulgaria, Chile, China, Columbia, Cyprus, Egypt, India, Indonesia, Mexico, Peru, Philippines,	<i>'Permanent members':</i> Hungary, Czech Republic, Malaysia, Malta, Slovenia,



Iran (I. R.), Kenya, Sudan, Myanmar, Nigeria, Pakistan, Tanzania, Viet Nam  <i>'Non-permanent members'</i> : Colombia, Pakistan	Russia, South Africa, Romania, Thailand, Turkey, Venezuela			Slovak Republic  <i>'Non-permanent members'</i> : Estonia, Greece, Lithuania, Latvia, Poland, Portugal, Ukraine
	<b>G2a*</b>	<b>G2.b*</b>	<b>G2c*</b>	
	Bulgaria, Colombia, Indonesia, Peru, Philippines, Romania, Turkey, Ukraine	Argentina, Brazil, China, India, Mexico, South Africa, Thailand	Chile, Cyprus, Greece, Egypt, Latvia, Lithuania, Poland, Portugal	

\*Note: G2a, G2b and G2c arise for the 9 cluster solution when Ward's method for linking the different cases is used. In these circumstances some NISs that were part of G1 or G3 are 'captured' into the larger group of countries that made up G2.

As the Developed NISs megacluster is concerned, despite an overall smaller membership, the situation is more complex. This reflects a larger heterogeneity among the NISs that are part of this megacluster, suggesting that as the different NISs become more developed they may probably evolve into more specific types of NISs. For the sake of simplicity however, and in accordance to our interpretation of the existing evidence, we will retain 4 major groups (G4, G5, G6, G7), or 'types' of NIS within M1.<sup>6</sup> These 4 groups were classified as: Natural Resources-Based NISs; Services-Oriented NISs; High Tech Smaller NISs; and the Larger Developed NISs (see table 5).

Starting with G4, it integrates economies characterized by good natural resources endowments (grazing land, oil and other minerals, sun and beaches...) and which display an international specialization reflecting that fact. When comparing with the remaining economies of M1, G4 NISs tend not to perform very well both on innovation and diffusion. Next, G5 integrates 4 quite idiosyncratic economies which, as seen, in two cases (Luxembourg and particularly Hong Kong) 'flow' sometimes to M2 or tend to stay out of both M1 and M2. Those 4 economies tend to be very specialized in quite different types of production, ranging from low to high tech, and their services sectors play a very significant role in their international specialization. In relation to G6, the NISs in this grouping share some characteristics with those in G5 (namely they are small open economies with a high degree of specialization), but they tend to be much more concentrated on high tech manufactures. Moreover they are doing very well in both innovation, diffusion and intangible accumulation. Finally, G7 aggregates the larger OECD economies (being Taiwan an 'outlier' in this regard). These NISs are doing relatively better on innovation than in diffusion. This characteristic is shared with the larger emerging NISs that make up G2.b, confirming that a scale effect might be present in explaining a relatively better performance on innovation.

<sup>6</sup> In several runs a larger number of clusters arise within M1. In the limit, in one run 7 clusters emerge. That is when some of the catching up NISs move from M2 to M1.

**Table 5**  
**A partition of the Developed NIS megacluster**

<b>G4 - Natural Resources-Based NISs</b>	<b>G5 - Services-Oriented NISs</b>	<b>G6 - High Tech Smaller NISs</b>	<b>G7 - Larger Developed NISs</b>
<i>'Permanent members':</i> Australia, New Zealand, Norway	<i>'More Permanent members':</i> Denmark (8), Belgium (7), Luxembourg (6)	<i>'Permanent members':</i> Finland, Ireland, Netherlands, Singapore, Sweden, Switzerland	<i>'Permanent members':</i> France, Germany, Italy, Japan, Korea, Taiwan, UK, US
<i>'Non-permanent members':</i> Austria (4), Canada (4), Spain (4)	<i>'Less permanent member':</i> Hong Kong (3)		

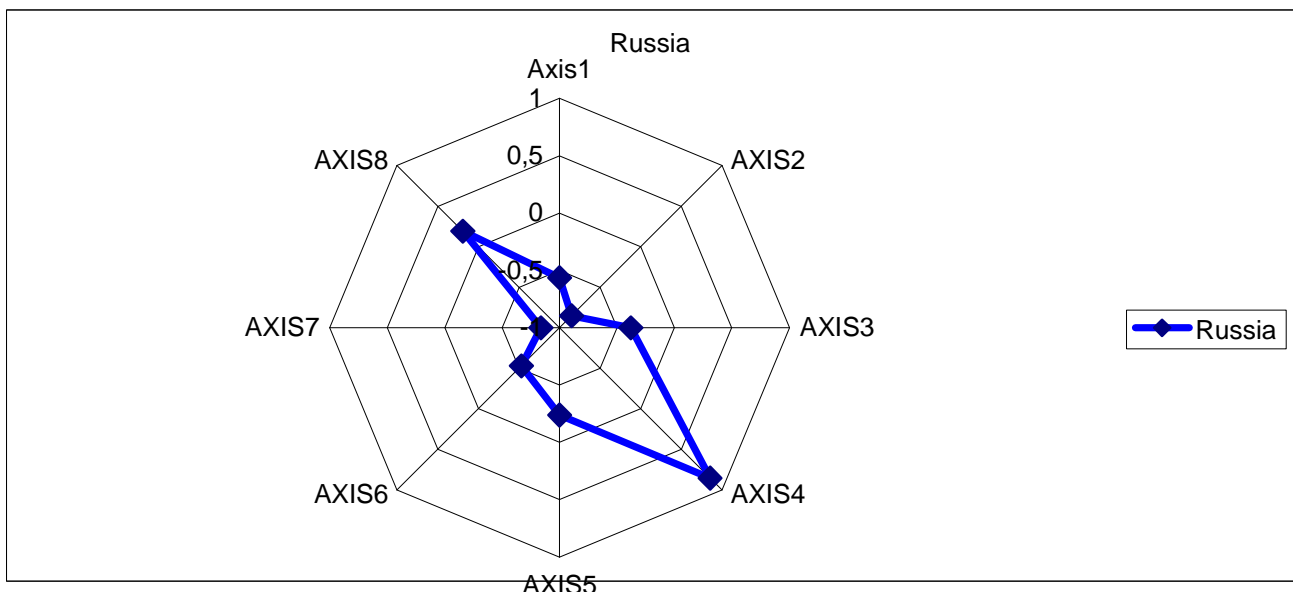
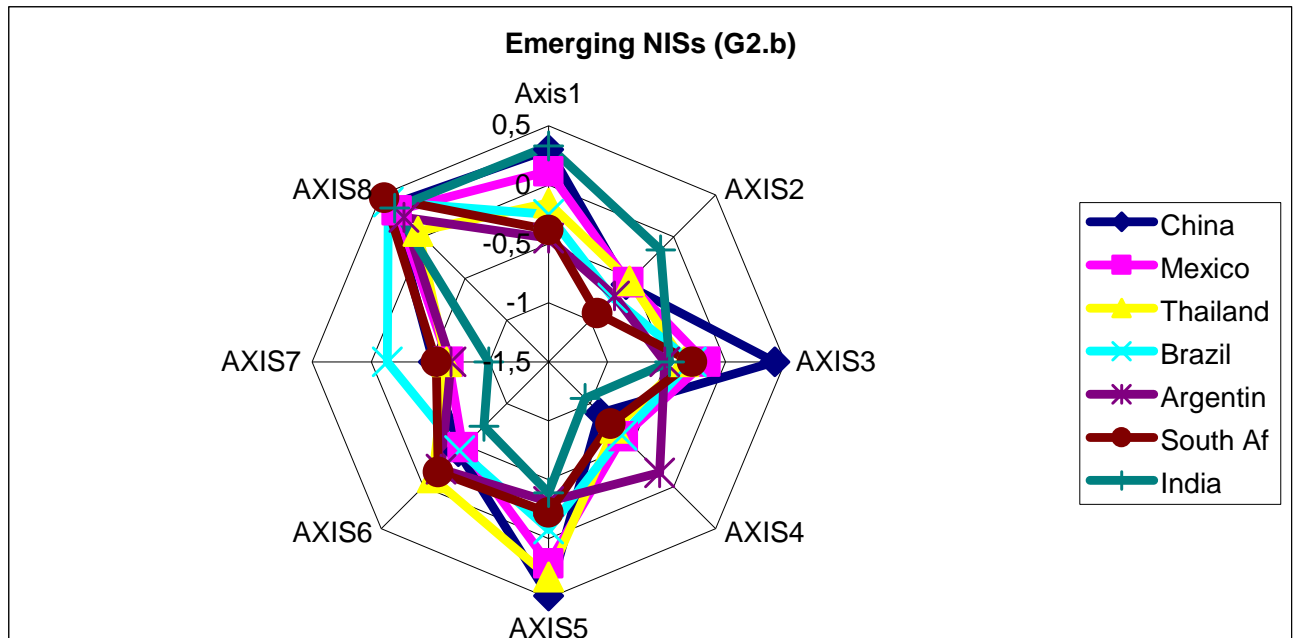
\*Note: The numbers between brackets identify the number of cluster analysis runs (out of the total 9 runs) in which those NISs came together.

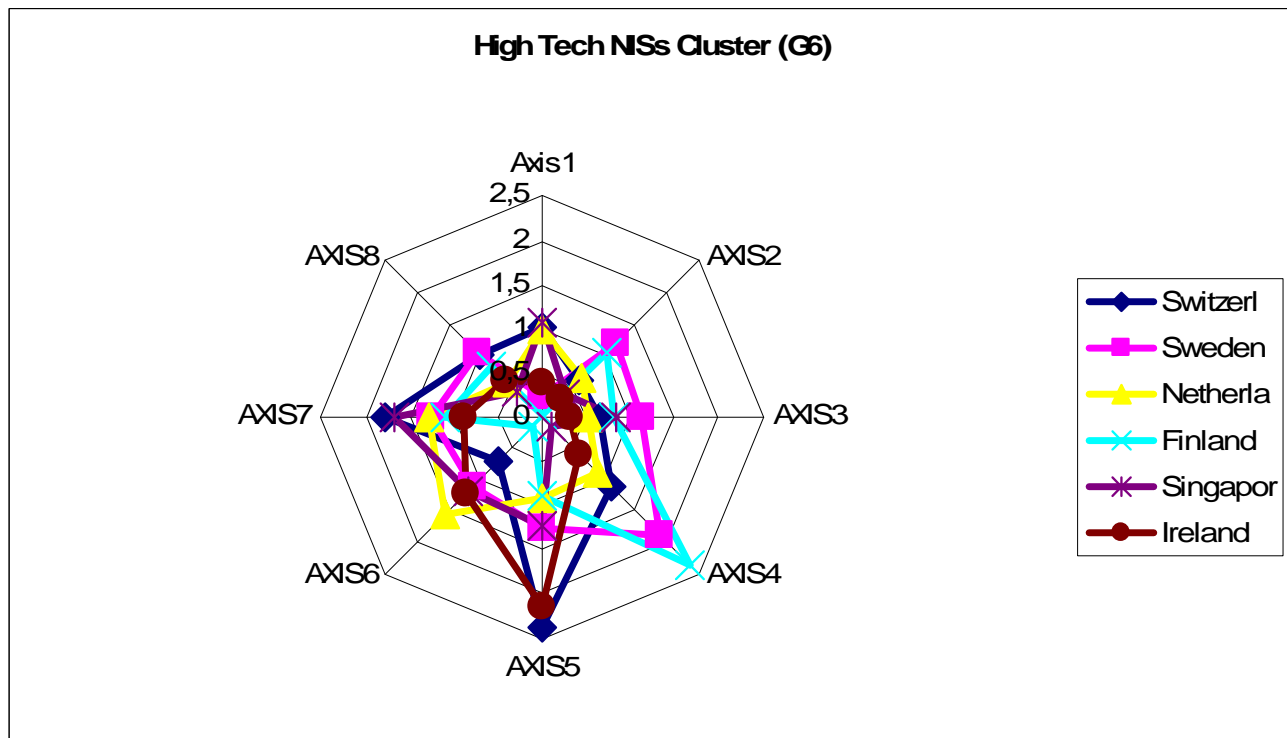
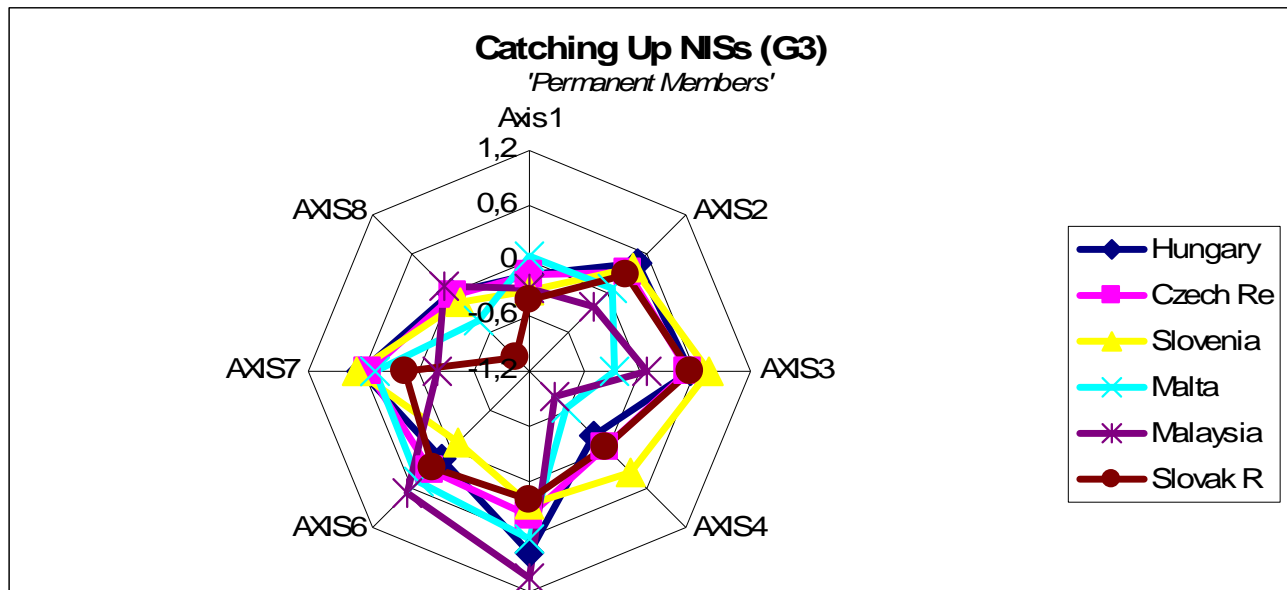
#### **4.2. Mapping NISs (dimensions, size, ranking)**

Having gathered, processed, summarized and critically observed all the necessary information, we are now able to represent the results for each NIS dimension along eight axes, using the so-called radar-type charts. This sort of graphic representation has many advantages. Information visualization is often a neglected aspect of academic communication. However, from the point of view of social science users such as policy makers, seeing information may allow clearer interpretation of trends, more effective identification of anomalies and faster decision-making. With so many institutions generating huge quantities of data, images actually constitute a easy way to absorb information. Techniques for capturing vast amounts of information in one picture are likely to be in great demand from individuals for which time and attention are the scarcest of resources.

We could have presented the charts we will be now showing before the cluster analysis, but we are doing it now because in this way we can compare countries in the same cluster groupings. As an alternative, we might for example have presented countries belonging to the same continent or economic region in different graphs.

The radar-type charts show the configuration of each NIS or group of NISs in accordance to their respective performances along the eight axes. Each axis in the chart varies around zero (e.g. between -3 and 3), being zero an equivalent to the standardized means. The charts are illustrative of the relatively stronger and weaker points of each system and the cluster groups they belong to. We are presenting below just a few charts to exemplify the potentialities of the mapping technique.





The type of information presented in the previous figures allows one to estimate for each NIS both its “size” and discuss its uneven *vs.* balanced nature. NIS size, or total NIS dimension, might be calculated as the area within the line that represents each country in the chart. However, a simpler way of doing this is by calculating the mean of the values each country displays on the eight NIS dimensions. For the countries in the sample the values stemming from this calculation have the same relative distribution

has the areas in the charts. A NISs ranking produced through these steps is presented in table 6 below.

Table 6. NIS ranking

1. Switzerland	1,15	24. Hungary	0,27	47. India	-0,39
2. Sweden	1,13	25. Czech R.	0,23	48. Turkey	-0,42
3. Netherlands	0,91	26. Slovenia	0,23	49. Ukraine	-0,43
4. Denmark	0,90	27. New Zealand	0,21	50. Egypt	-0,43
5. Finland	0,90	28. Portugal	0,13	51. Romania	-0,45
6. Hong Kong	0,90	29. Malta	0,05	52. Venezuela	-0,52
7. United Kingdom	0,88	30. Malaysia	0,05	53. Bulgaria	-0,56
8. United States	0,86	31. Slovak R.	0,00	54. Indonesia	-0,58
9. Singapore	0,86	32. Greece	-0,07	55. Morocco	-0,59
10. Japan	0,85	33. China	-0,10	56. Viet Nam	-0,59
11. Germany	0,81	34. Estonia	-0,11	57. Colombia	-0,63
12. Ireland	0,81	35. Poland	-0,12	58. Algeria	-0,67
13. Korea (R. of)	0,67	36. Mexico	-0,23	59. Peru	-0,68
14. France	0,62	37. Cyprus	-0,26	60. Iran (I.R.)	-0,75
15. Taiwan	0,60	38. Thailand	-0,26	61. Bangladesh	-0,77
16. Austria	0,57	39. Brazil	-0,27	62. Pakistan	-0,82
17. Norway	0,51	40. Lithuania	-0,29	63. Nigeria	-0,89
18. Belgium	0,50	41. Chile	-0,29	64. Kenya	-0,94
19. Spain	0,50	42. Russia	-0,30	65. Ethiopia	-0,97
20. Canada	0,44	43. Latvia	-0,30	66. Myanmar	-0,98
21. Italy	0,44	44. Argentina	-0,35	67. Tanzania	-0,99
22. Austrália	0,40	45. South Africa	-0,35	68. D.R. Congo	-1,05
23. Luxembou	0,38	46. Philippines	-0,36	69. Sudan	-1,06

The discussion of the unevenness of the system can be done by simply observing the charts to see whether the country has a regular shape with all eight dimensions showing a similar length, or otherwise it can be calculated as the standard deviation of the country's values in each of the eight axes. We are not presenting here figures for this, but in Godinho et al. (2003) we have exemplified this process.

## 5. Conclusion: Towards a NISs taxonomy

The analysis developed above will now be re-examined. First we will concentrate on the method that has been suggested for mapping national innovation systems. Next we will return to the results of the clustering exercise, which was carried out in order to helping us to envisage a NISs taxonomy. Finally, we conclude with some remarks on the normative implications and elaborate on further research needs in this area.

### Some conclusions regarding the NIS mapping technique

The exercise that was carried out shows that the NIS mapping technique we have deployed although simple in the steps it requires has significant analytical potential. In what regards the analytical value, we are aware that different arguments may be raised in relation to the process that led us to the identification of eight major NIS dimensions. Even though we think those dimensions are sound and credible, we think that what is strategically more important is the process involved in their definition. This is so because by getting involved in that process one is forced to be specific about what

exactly is meant by “national innovation system”, concentrating on the aspects that deserve to be analysed with greater attention. Such process might help the conceptual work in this area to evolve further in the future, moving out of vague discussions to more precise definitions of “NIS” and its components.

### **Main results from the cluster analysis**

The cluster analysis that was implemented generated several major results.

A first result is that two quite distinct ‘megaclusters’ – the ‘Developed NISs’ and the ‘Developing NISs’, respectively – emerge. The algebraic distance between these two groupings constitutes evidence of very important qualitative and quantitative differences between them. This may be seen as indicating that the NIS concept has actually different meanings when applied to countries at different development levels. Further that differentiated nature suggests that important endogenous changes might occur in the countries pertaining to the Developing NISs in order to jump over the huge gap that separates the two megaclusters.

A second indication stemming from the analysis is that in the process of advancing from lower to higher development status, the different NISs tend to evolve into a more diversified pattern of NIS types. This may happen because higher development levels might be associated with more specialized patterns of activity which generate greater variety in NIS types.

A third possible conclusion is that when one speaks about the configuration of innovation systems ‘size matters’. It seems that the larger economies perform relatively better in innovation than in diffusion. This suggests that a scale effect might interfere in the pattern of innovative activities of an economy.

Finally one concludes that both the patterns of specialization and the economic structure, being them determined by natural resources endowments, historical trajectories, or size and degree of external openness of the economy, seem also to affect strongly the configuration of national innovation systems.

### **Normative implications and further research**

In what concerns the practical policy-making dimension, the cartography of NISs that was produced through the method put forward, together with its associated indicators and the taxonomy we have drawn above, indisputably show high potential. In this respect, it is clear that our work follows in line with some key recommendations of the innovation systems research: «Concrete empirical and comparative analyses are absolutely necessary for the design of specific policies in the fields of R&D and innovation. The S[systems of] I[nnovation] approach is an analytical framework suited for such analyses. It is appropriate for this purpose because it places innovation at the very centre of focus and because it is able to capture differences between systems. In this way specific problems that should be objects of innovation policy can be identified.» (Edquist 2002, p. 22).

On the policy side we must also recall here the conclusions of a OECD project on “Dynamising National Innovation Systems”: «the need to engage in effective learning processes suggests that governments may benefit from intensified international benchmarking of policy practices in this [NIS] respect» (OECD 2002, p. 81).

In conclusion, it becomes clear that the mapping tool that was implemented fits well into the type of comparative and benchmarking analyses that have been sought both by academics and policy-makers. This tool has the advantage of avoiding the oversimplification that has been associated with many recent scoreboard exercises, which have tended to sum up the analysis to single summary measures of innovation. In contrast, our method allows for a clear identification of the weakest and strongest dimensions of each NIS. Moreover, and as it was shown, this tool and the resulting taxonomy have policy-making value for both the advanced countries, the intermediate catching up countries and the developing economies as well.

To finalise with we must say that besides eventual disagreements that may arise in what concerns the definition of the NIS dimensions etc., an aspect that we are aware is the incompleteness of the present exercise in terms of several key indicators that are lacking. Among others, there are three key areas in which indicators do not exist for such a larger sample as the one we were dealing with. First, there is no comprehensive and updated data for the nature of the R&D activities in many countries, detailing the share of business in total GERD or identifying the relative weight of basic and applied R&D. Second, the number of indicators regarding *innovation* we can mobilise for a comparative exercise like the present one is still very limited. Surveys like CIS in Europe must be promoted elsewhere to supply indicators about the outputs of the innovation process. In Latin America a good deal of work on this has been done. This together might be an impulse for a wider and globally more planned establishment of innovation surveys. Finally, a third area in which we critically need information is about the type and quality of interactions established within the innovation systems. Indicators such as “Business funding of government and university R&D”, “R&D arrangements between firms and university or Research and Technology Organizations”, or yet “SMEs in cooperation to innovate” are critically needed so that a better characterization of innovation systems might advance further.

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万有引力常数  $G$  的测定  $\Rightarrow$  卡文迪许实验  $\Rightarrow$  扭秤实验

