# Mapping Innovation Systems:
## A Framework Based on Innovation Data and Indicators

**Preliminary draft**

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**Abstract:**

This paper addressed the following questions: Is it possible to measure National Innovation Systems (NISs)? What specific technique may be used for that? Can we apply that technique to both the advanced and the catching up economies? The experimental exercise that was carried out in mapping fourteen NISs shows that positive replies can be given to those questions. The technique which was put forward, although simple in the steps it requires to produce the graphical representations and the quantitative indicators of NISs, shows a significant potential for both analytical and policy-making purposes. The cartography that was produced allows one to compare different national innovation systems, by visualizing in bi-dimensional space the graphic pattern of the relevant dimensions of each NIS. In addition to that it also allows each individual NIS, weather it is from an advanced or a catching up economy, to detect its weaker and stronger dimensions, to assess its evolution from one moment in time to another, and to determine whether its development has been balanced or on the contrary uneven.

## 1. Introduction

The purpose of this paper is to put forward a tool for mapping "national innovation systems". Such mapping will allow the comparison of different national innovation systems, by visualizing in bi-dimensional space the graphic pattern of the relevant dimensions of the "national innovation system" (NIS). In addition to this comparison, this tool also aims at allowing for each individual NIS to detect its weaker and stronger dimensions, to assess its evolution from one moment in time to another, and to determine whether its development has been balanced or on the contrary uneven.

The problem we are therefore dealing with in this paper is the possibility of measuring the maturity and development pattern of different NISs, through a cartography of their relevant dimensions. The objective of this process, that combines quantification with the use of a graphical technique, is allowing for inter- and intra-NIS comparisons in a given moment and across time.

In contrast to this approach many would argue that the NIS concept might not be amenable to quantification. This is so because, along the functional dimensions which refer to the actors' roles and the interactions connecting them, this concept has emphasized innovation as a socially embedded process, stemming from a set of intangible dimensions – scientific knowledge, technology, institutional arrangements – which are essentially qualitative in their nature.

We will however show that despite the prevalence of those intangible aspects, given certain assumptions and by using adequate sets of data and indicators the mapping and quantification of innovation systems is a feasible enterprise. In the sequence of the present introduction, section 2 is dedicated a summary of the NIS rationale. Then in section 3 we will put forward a conceptually sound framework of NIS dimensions, providing indications with respect to what are the critical NIS dimensions to be retained and how they can be represented by different types of indicators. From this we will map in section 4 different countries' NISs in two points in time, providing a cartography of NIS maturity and evolution. Finally in the concluding section we will point out the main limitations of this exercise, and also the many possible useful uses to which this tool for analysing NISs can be helpful.

## 2. The NIS rationale

The 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) used this concept in his discussion of the Japanese innovation system, while Lundvall (1985, 1992) and others applied it in connection to the empirical observation of the interactions and institutional framework that supported innovative activities in the small open economies of Scandinavia. 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.

The NIS approach has meanwhile developed significantly, and several other associated concepts have emerged stressing different aspects. 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) or Landabaso (1995) 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 and Orsenigo 1993 and 1997), 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 NIS 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 "innovation systems" concepts sprung up from the original NIS concept. Rather we are interest in the original concept and our analysis is centred on the national level, with the objective of promoting a cartography of NISs development. The main question that we are addressing in the paper has to do with knowing whether it is acceptable to measure and represent NISs development and, if positive, whether a practical and consistent technique can be put forward in order to achieve that purpose.

As it was already pointed out in the introduction, it has been argued that the NIS concept is essentially a qualitative concept not easily amenable to quantitative treatment. This argument can be understood if one considers that the initial theorisation and its several variations have tried to combine the (mainly quantitative) economic analysis of innovation with insights into several critical intangible (qualitative) dimensions that affect innovation patterns and dynamics.

The NIS concept preceded somewhat in time 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 NIS 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 they have allocated 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 different 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. According to the argument we have been referring to, it is this qualitative nature of innovation that challenges the quantification enterprise.

However, at least two recent developments can be considered as weakening that argument. 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 diversity 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 and R&D statistics.

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' 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".[1] This type of exercise has been criticized, by 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 2003). 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.

We shall add that this need for summarizing the multidimensionality of the NIS reality goes beyond the quest of policy makers in advanced economies. As it was pointed out before, the NIS concept was initially applied to some of the more advanced economies. But, in the sequence of the seminal contributes of Freeman and Lundvall, the research that has contributed to the NIS approach has spread also to several intermediate catching up economies more recently. These recent developments have raised the

[1] In 2000 the EU Lisbon summit decided to develop a European Innovation Scoreboard, which is an example of this approach.

methodological problem of knowing whether the NIS concept is adequate for application to all types of economies, regardless the actual maturity of their innovative capabilities. Through the technique that will be proposed in the next section, we can experimentally test the validity of applying the NIS concept to those economies.

## 3. A method for measuring and mapping the patterns of national innovation systems

In order to provide an answer to the questions raised above, we will turn next to a decomposition of NIS in terms a set of major dimensions. In the sequence we will discuss what indicators might be adequate to represent each of those major dimensions and how we can graphically depict them.

### 3.1. Relevant NIS dimensions

Most of the graphical representations of a NIS which have been presented in the literature tend to concentrate on the actors and the linkages that typically connect them. We think however this is an oversimplification of the NIS reality. The NIS concept can be seen as a systemic model of the innovation process, growing out of the innovation theory advancements since the classic pipe-line 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 model of innovation (Kline and Rosenberg 1986), were integrated in the NIS theoretical framework.

We must therefore consider, in addition to the “process” itself in which the actors are directly involved through their own activities and interactions, the inputs and outputs of that process. In other words, one needs to consider on the one side the resources invested in innovation and on the other side the results stemming from the combination of those resources. In this case the major results from a NIS have naturally to do with the system’s innovation performance, but also, and this is a very important aspect, 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 distributional 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. This perspective of industrial organization can be seen as critical of the mainstream view that the central factor regulating modern economies is the competition that arises between independent firms. Competition is also an important factor in the NIS approach, but it is seen as mainly a “Schumpeterian competition” in which firms strive for the introduction of better products, improved processes, alternative supplying sources and innovative organizational arrangements (Fagerberg 2003).

In addition to the competitive action of firms, in the NIS approach other actors are also relevant in bringing about innovation. These include the universities, the public labs, a diversity of other non-profit and profit RTO organizations or the intermediate transfer agencies and brokers, among others. Institutional diversity – including the regulatory procedures, conventions and aspects that affect the attitudes and behaviours of economic agents– is therefore a critical structural property to be considered in the observation of the "completeness" of the innovation system.

Another structural dimension that needs to be considered, and that results largely from the Schumpeterian competition process referred to above, is the sectoral structure of the economy. 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, we will therefore need to know how the economic activity is distributed through sectors with different R&D and knowledge intensities.

Finally, another critical aspect that deserves attention, when considering the characteristic traits of a NIS, has to do with the discussion of the frontiers of the innovation system. It has been discussed whether in an era of globalisation the "national" level of analysis retains the same relevance it had before, particularly when a great share of innovating activities is generated within large multinational firms (Pavitt and Patel 1988, Patel 1995, Pavitt and Patel 2000). What comes out from empirical research in this regard is that the national level of analysis remains relevant to understand innovation, not only for small- and medium-sized firms but also for the very large firms that have retained most of their R&D activities in their home countries. However, it has also been shown that significant international technology flows are associated with the transnational activities of some of those very large firms, both through carrying out a larger share of R&D activities abroad (Meyer-Krahmer et al. 1998) or through the more classical ways of embodied technology and FDI. In any case, the external communication of each NIS shall be seen as a relevant analytical dimension. Particularly for catching up economies, this link is vital for allowing the absorption of foreign knowledge and the diffusion of new technologies.

### 3.2. Methodological steps in the NIS mapping exercise

From the discussion above we draw the following eight major dimensions as being representative of the NIS multidimensionality:

- Resources supply;
- The actors and their behaviours;
- Interactivity and linkages;
- Institutional diversity and development;
- External communication ("absorption");
- Economic structure;
- Innovation;
- Diffusion.

Table 1 below identifies the indicators that were kept as representing better each of those dimensions. That table also provides information about the sources and other details related to each indicator.

We sought in this exercise to retain a diversity of indicators, based on different types of variables (stock and flows, monetary and physical), in order to provide information about the eight dimensions. In these indicators' selection we tried to consider not only those that represent the actual innovation capabilities and performances, but also those who might provide a dynamic outlook of the innovative potential (e.g.: scientific publications, new scientists and engineers leaving higher education).

We are aware that many of the selected indicators do not constitute optimal solutions for portraying the different dimensions of a NIS. However, in this exercise we had to act pragmatically, choosing the indicators according to their accessibility, reliability and adequate coverage of the period to be observed. The identification of this period was also limited by data availability. We therefore retained "1996" and "2000" as the two moments of observation, with many of the indicators providing information for one-plus or one-less year in relation to those two dates. In some cases we were even forced to consider other years outside those limits, being a common situation for a few variables the use of the same figures both in the initial and latter moments.

## Table 1. Variables used in mapping NIS dimensions and evolution

| Code | Variable Name (V2-V46)<br>NIS Dimensions (G1-G8) | Year 1 (1996) | Source | Page | Year 2 (2000) | Source | Page | Notes |
|---|---|---|---|---|---|---|---|---|
| G1 | *Resource Supply* | | | | | | | |
| V2 | R&D financed by government/GDP (%) | 1995 | 1 | 293 | 2001 | 1 | 293 | |
| V3 | R&D financed by industry/GDP (%) | 1995 | 1 | 293 | 2001 | 1 | 293 | |
| **V4** | **Venture capital Investment/GDP** | 1997 | 3 | 55 | 2001 | 4 | 154 | |
| V5 | Researchers per 10,000 labour force | 1995-96 | 1 | 312 | 1999-00 | 1 | 312 | |
| V6 | Population 25-64 y.o. with tertiary education | 1996 | 3 | 120 | 2000 | 6(+1) | (311) | |
| G2 | *Actors' behaviour* | | | | | | | |
| V7 | BERD/GDP (%) | 1997 | 2 | 236 | 2001 | 1 | 297 | |
| V8 | HERD/GDP (%) | 1997 | 2 | 236 | 2001 | 1 | 297 | |
| V9 | Flows of graduates in S&E | 1998 | 2 | 225 | 2000 | 6 | | (1) |
| V11 | PhDs in S&E per 1000 in the age group 25-34 | 2000 | 4 | 188 | 2000 | 4 | 188 | = |
| V12 | Life-long learning | 2000 | 5 | | 2001 | 6 | | ≅ |
| V13 | Scientific publications per million inhabitants | 1996 | 1 | 317 | 2000 | 1 | 317 | |
| G3 | *Interactions and linkages* | | | | | | | |
| V14 | Business funding of gov. and univ. R&D (%) | 1997 | 3 | 136 | 1997 | 3 | 136 | = |
| V15 | R&D arrangements between firms and gov. or univ. org. (%) | 1994-96 | 3 | 136 | 1994-96 | 3 | 136 | = |
| **V16** | **SMEs in cooperation to innovate (%)** | 1996 | 5 | | 1996 | 5 | | = |
| V17 | Average nº of scientific articles in EPO patents | 1992-96 | 4 | 421 | 1992-96 | 4 | 421 | = |
| G4 | *Institutional diversity and development* | | | | | | | |
| V18 | Density of R&D matrix | | | | | | | (2) |
| V19 | BERD/GERD (%) | 1995 | 1 | 295 | 2001 | 1 | 295 | |
| **V4** | **Venture capital Investment/GDP** | 1997 | 3 | 55 | 2001 | 4 | 154 | = |
| **V16** | **SMEs in cooperation to innovate (%)** | 1996 | 5 | | 1996 | 5 | | = |
| G5 | *External communication ("absorption")* | | | | | | | |
| V21 | TBP payments/GDP | 1997 | 3 | 171 | 2001 | 1 | 320 | |
| V22 | Domestic ownership of foreign inventions | 1993-95 | 2 | 251 | 1993-95 | 2 | 251 | = |
| V23 | R&D financed by foreign sources/GERD (%) | 1997 | 2 | 231 | 2001 | 1 | 292 | |
| V24 | R&D expenditures by foreign affiliates/BERD (%) | 1995-97 | 2 | 307 | 1997-99 | 2(+4) | 307(123) | |
| V25 | Scientific publications with a foreign co-author (%) | 1995 | 3 | 164 | 1995 | 3 | 164 | = |
| V26 | Patents with foreign co-inventors (%) | 1993-95 | 3 | 164 | 1993-95 | 3 | 164 | = |
| V27 | High-tech imports/GDP (%) | 1998 | 7 | 69 | 1998 | 7 | 69 | = |
| V28 | FDI inflows/GDP (%) | 1995 | 1 | 325 | 2000 | 1 | 325 | |
| G6 | *Economic Structure* | | | | | | | |
| V29 | Share in R&D expenditures of top 500 companies/GDP (%) | 2000 | 4 | 139 | 2000 | 4 | 139 | = |
| V31 | High tech-industries in business sector value-added (%) | 1995-97 | 2 | 220 | 1999-00 | 1 | 286 | |
| V32 | Knowledge-intensive services in business sector value-added (%) | 1995-97 | 2 | 220 | 1999-00 | 1 | 286 | |
| V33 | High-tech exports/GDP (%) | 1998 | 7 | 69 | 1998 | 7 | 69 | = |
| G7 | *Innovation* | | | | | | | |
| V34 | USPTO patents granted/population | 1996 | 2 | 256 | 1999 | 2 | 256 | |
| V35 | High tech EPO patents/population | 1999 | 5 | | 2000 | 6 | | |
| V36 | Revealed comparative advantage in high tech exports | 1998 | 7 | 69 | 1998 | 7 | 69 | = |
| V37 | New to market products in total sales | 1996 | 5 | | 1996 | 5 | | = |
| G8 | *Diffusion* | | | | | | | |
| V38 | ICT expenditures/GDP (%) | 1996 | 2 | 221 | 2000-01 | 6 | | |
| V39 | Cell-phones per 100 inhabitants | 1996 | 3 | 118 | 2000 | 9 | 186-7 | |
| V41 | Internet hosts per 1,000 inhabitants | 1997 | 1 | 327 | 2000 | 1 | 327 | |
| V42 | Personal computers per million inhabitants | 1996 | 8 | | 2000 | 8 | | |
| V43 | Gross fixed capital formation/GDP (%) | 1998 | 1 | 285 | 1998 | 1 | 285 | = |
| | OTHER VARIABLES (Auxiliary) | | | | | | | |
| V44 | Innovation expenditures as a % of turnover | 1996 | 5 | | 1996 | 5 | | = |
| V45 | Population 2000 | 2000 | 9 | 162-3 | 2000 | 9 | 162-3 | = |
| V46 | GDP 2000 | 2000 | 9 | 190-1 | 2000 | 9 | 190-1 | = |

**Sources**: 1. OECD, STI Outlook 2002; 2. OECD, STI Outlook 2000; 3. OECD, STI Scoreboard 1999; 4. Third European Report on S&T Indicators 2003; 5. European Innovation Scoreboard 2001; 6. European Innovation Scoreboard 2002; 7. EUROSTAT, Key Figures 2000, Towards a ERA; 8. Dados F&G 2004; 9. UNDP, Human Development Report 2002.

**Notes**: (1) Year 1 and Year 2 in different bases: Y1 - Flows of graduates in S&E/total employment (%); Y2 – New S&E graduates per thousand 20-29 years old; (2) Not included in the calculations; = Means that the same information was used for "Year 1" and Year 2"; Bold is used for variables which were included in more than one dimension.

The 38 relevant variables listed above were transformed using a conventional standardization procedure. The next step was the aggregation of the variables in each group. Similar weights were used for the variables. A possible variation in future replications of this exercise would be the selection of different weights for the variables according to the importance ascribed to them in the innovation dynamics. Given the procedure highlighted above we reached eight composite indicators, one for each of the NIS dimensions presented before.[2]

For several variables information only existed for part of the countries in the sample. The most remarkable case in this respect is the CIS indicators, which only exist for the European economies. In all these cases and for each of the eight dimensions, the composite measure 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 economies, all of them with a diversity of geographical origins (Americas, Asia, Europe). On the whole, 14 countries were included in this exercise.

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. Each axis in the chart varies between –2 and 2, with zero being the value of the standardized mean. We will turn now in the next section to the results of the exercise.

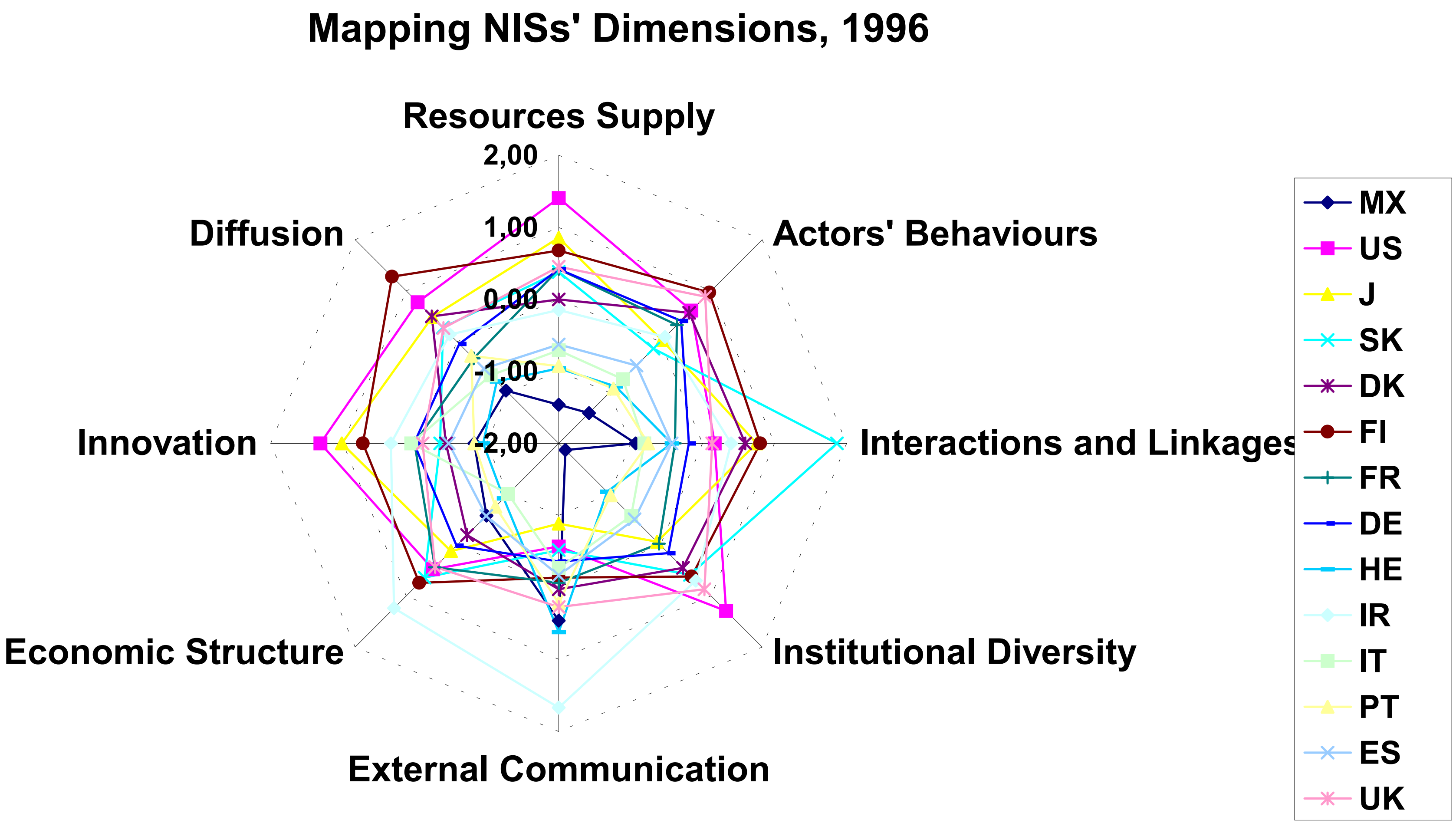
**4. Mapping NISs: assessing their patterns, size and evolution**

The main results are presented in figures 1 and 2, which display information for all the 14 countries in the sample respectively in years 1996 and 2000. The charts provide the mapping of each NIS along the eight dimensions we have been discussing.

The figures are illustrative of the relatively stronger and weaker points of each system. For example, the observation of the "institutional diversity " axis shows that this is a strong aspect of the US NIS, while for Mexico this is clearly a weak aspect. The US advantage has certainly to do with a very dynamic risk and venture capital industry.

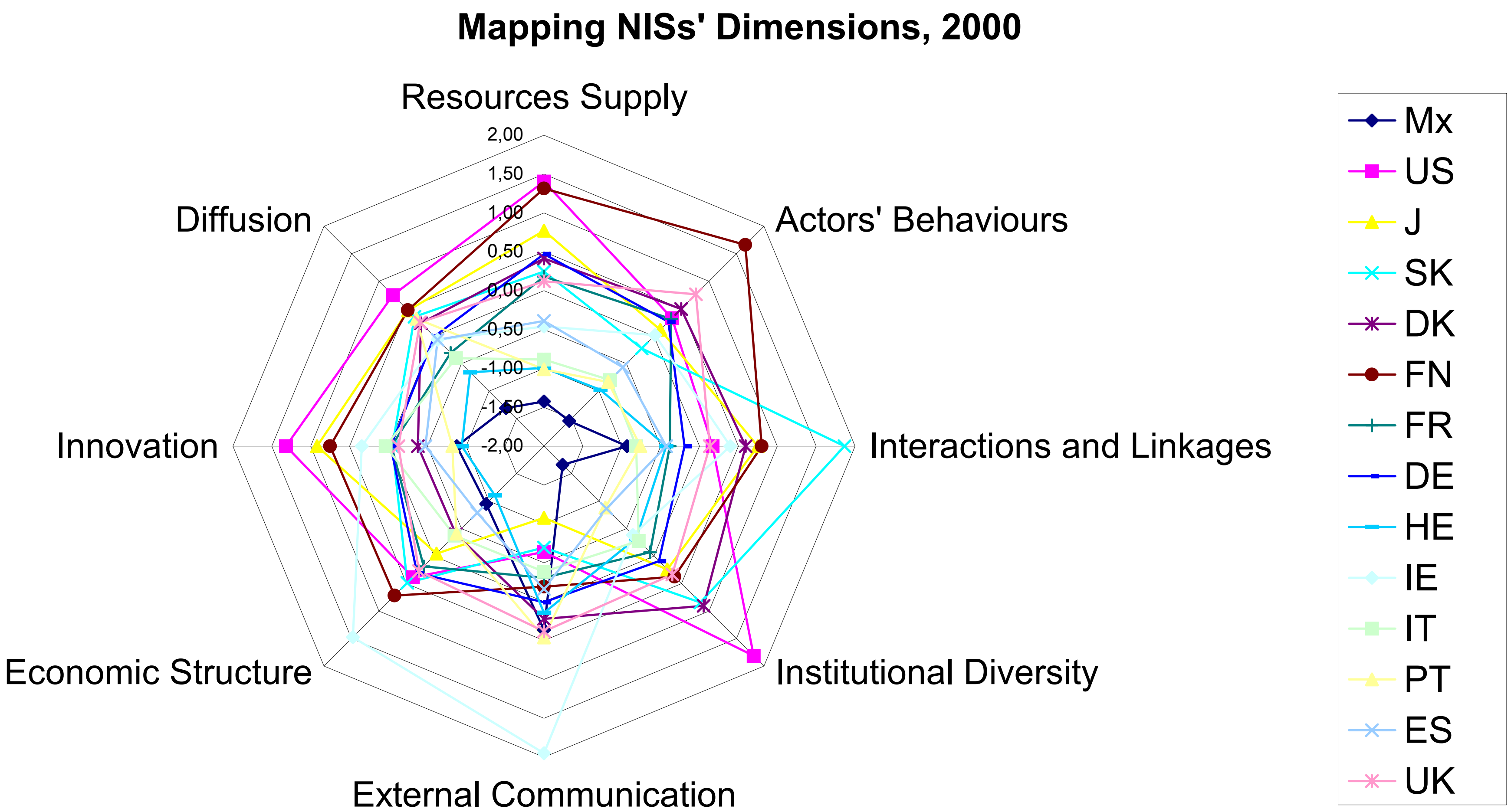
[2] In what regards the use of composite indicators, the notes in Eurostat (2002) and European Commision (2003), respectively on pages 80 and 433, clarify some methodological aspects.

**Figure 1**



Mapping NISs' Dimensions, 1996
Resources Supply
Actors' Behaviours
Interactions and Linkages
Institutional Diversity
External Communication
Economic Structure
Innovation
Diffusion
2,00
1,00
0,00
-1,00
-2,00
MX
US
J
SK
DK
FI
FR
DE
HE
IR
IT
PT
ES
UK

**Figure 2**


Mapping NISs' Dimensions, 2000
Resources Supply
Actors' Behaviours
Interactions and Linkages
Institutional Diversity
External Communication
Economic Structure
Innovation
Diffusion
2,00
1,50
1,00
0,50
0,00
-0,50
-1,00
-1,50
-2,00
Mx
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ES
UK

The observation of the information in figures 1 and 2 allows one to estimate for each NIS both its “size” and discuss its uneven *vs.* balanced nature. NIS size, or total NIS dimension, was calculated as the area within the line representing each country, with a value of 0 being given to point –2 in the centre of the charts.[3] The values provided by this measurement method can be seen as equivalent to the summary measures provided by the innovation scoreboards we mentioned before. 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 similar distances to the centre of the chart, or in alternative it can be calculated as the standard deviation of the country’s values in each of the eight axes. The results for both these calculation procedures are displayed in tables 2 and 3 below.

Table 2 shows interesting information as regards the hierarchy of NIS size, with Ireland and South Korea ranking quite well, but with Italy ranking less well than what could be expected. This situation certainly has to do with the fact that indicators for the industrial structure were taken into the analysis, favouring the two countries mentioned in the first place. But it might well also to do with the consideration both in the “resources supply” and the “actors’ behaviours” dimensions of certain indicators of innovative potential, related to the stock and flows of advanced human resources into the economy. Observing both charts, it is clear that Italy fares well in the “innovation” axis but less so in all the other seven dimensions.

With respect to the unevenness vs. balanced nature of the NISs, some countries like Germany or France show a regular graphical pattern, with all the eight dimensions of their NISs displaying about the same size. Interestingly, some of the nations with relatively “larger” NISs, like the US and Japan, show “uneven” systems. This is a result that should be observed with caution, since this “unevenness” is relative and it is endogenous to the exercise itself: we are comparing each country’s values with a figure that can not be necessarily seen (by the simple fact that it is the sample’s mean) as being the “right” or balanced value. In any case, and perhaps not surprisingly, it shall be pointed out that the figures in table 3 also stress the “unevenness” of the Irish and Korean systems.

In the sequence of tables 2 and 3 we present four additional figures, for years 1996 and 2000, in which we divided the 14 countries’ sample into two groups (“leading” and “following” NIS). These figures are presented for the sake of facilitating observation, which may be more difficult when all the countries are charted together as in figures 1 and 2.

[3] This was done for practical reasons. The NIS area must be calculated only with positive values. For this we added 2 to the actual value displayed along each axis, with the figures now varying in the interval between 0 and 4 (while in the charts they vary in the interval from –2 to 2).

## Table 2 - "NIS size" - Estimated values

| 1996 | | 2000 | |
|---|---|---|---|
| Finland | 20,70 | Finland | 21,22 |
| US | 20,35 | US | 20,47 |
| Ireland | 18,39 | Ireland | 16,41 |
| UK | 16,26 | South Korea | 15,67 |
| South Korea | 15,49 | Japan | 14,56 |
| Japan | 14,77 | UK | 14,51 |
| Denmark | 13,49 | Denmark | 14,46 |
| Germany | 11,87 | Germany | 12,67 |
| France | 11,84 | France | 10,73 |
| Spain | 6,59 | Spain | 6,63 |
| Italy | 5,61 | Italy | 6,47 |
| Portugal | 5,11 | Portugal | 6,43 |
| Greece | 5,01 | Greece | 5,08 |
| Mexico | 3,14 | Mexico | 2,59 |

## Table 3 - "NIS Evenness"

| 1996 | | 2000 | |
|---|---|---|---|
| Spain | 0,14 | Germany | 0,22 |
| Germany | 0,27 | France | 0,26 |
| France | 0,32 | UK | 0,26 |
| Italy | 0,33 | Spain | 0,27 |
| UK | 0,34 | Italy | 0,32 |
| Denmark | 0,39 | Greece | 0,43 |
| Finland | 0,40 | Denmark | 0,46 |
| Portugal | 0,42 | Finland | 0,57 |
| Greece | 0,55 | Portugal | 0,57 |
| Ireland | 0,62 | Mexico | 0,64 |
| Japan | 0,62 | Japan | 0,64 |
| US | 0,67 | South Korea | 0,77 |
| Mexico | 0,70 | US | 0,79 |
| South Korea | 0,74 | Ireland | 0,87 |

Note: The "evenness" of a NIS was estimated for each country (and for each year 1996 and 2000) as the standard deviation of the country's values in the eight NIS dimensions. A value closer to zero means that the country has about the same relative "size" in each of the eight axes/dimensions. In contrast, a value closer to 1 means the country has an uneven system, with some of the eight dimensions scoring much better (or worse) than the others.

**Figure 3**

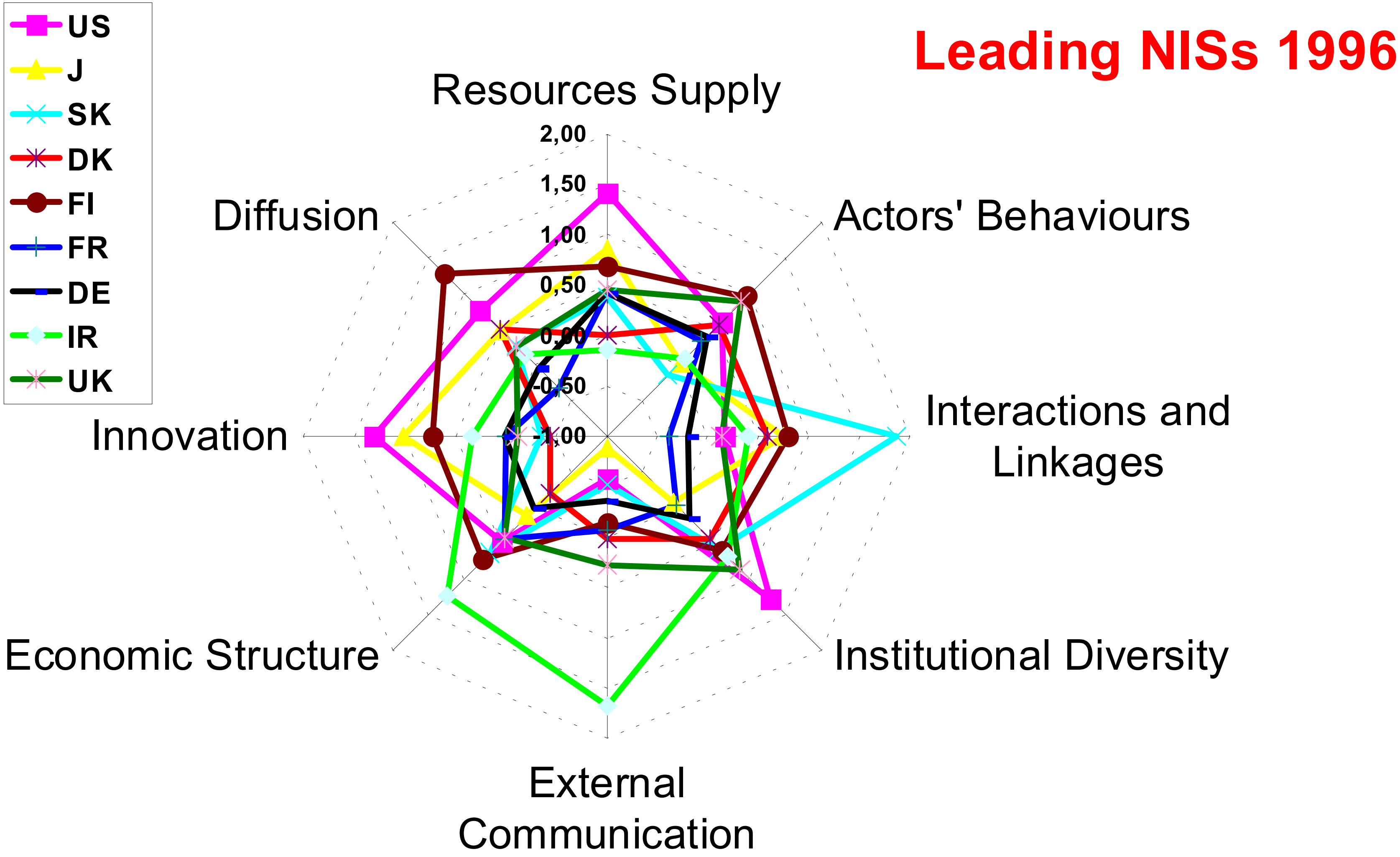

Leading NISs 1996
US
J
SK
DK
FI
FR
DE
IR
UK
Resources Supply
Actors' Behaviours
Interactions and Linkages
Institutional Diversity
External Communication
Economic Structure
Innovation
Diffusion
2,00
1,50
1,00
0,50
0,00
-0,50
-1,00

**Figure 4**

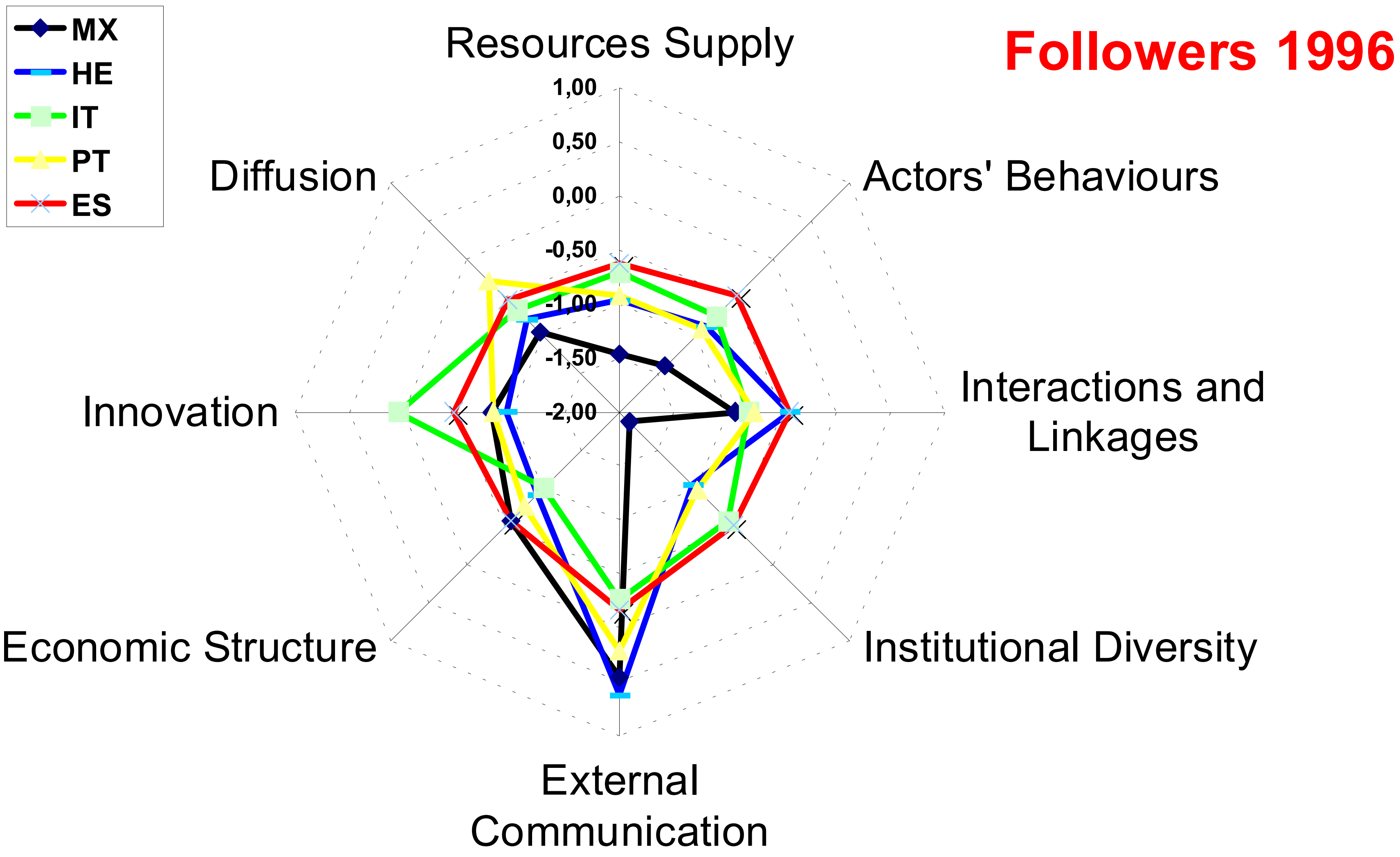

Followers 1996
MX
HE
IT
PT
ES
Resources Supply
Actors' Behaviours
Interactions and Linkages
Institutional Diversity
External Communication
Economic Structure
Innovation
Diffusion
1,00
0,50
0,00
-0,50
-1,00
-1,50
-2,00

**Figure 5**

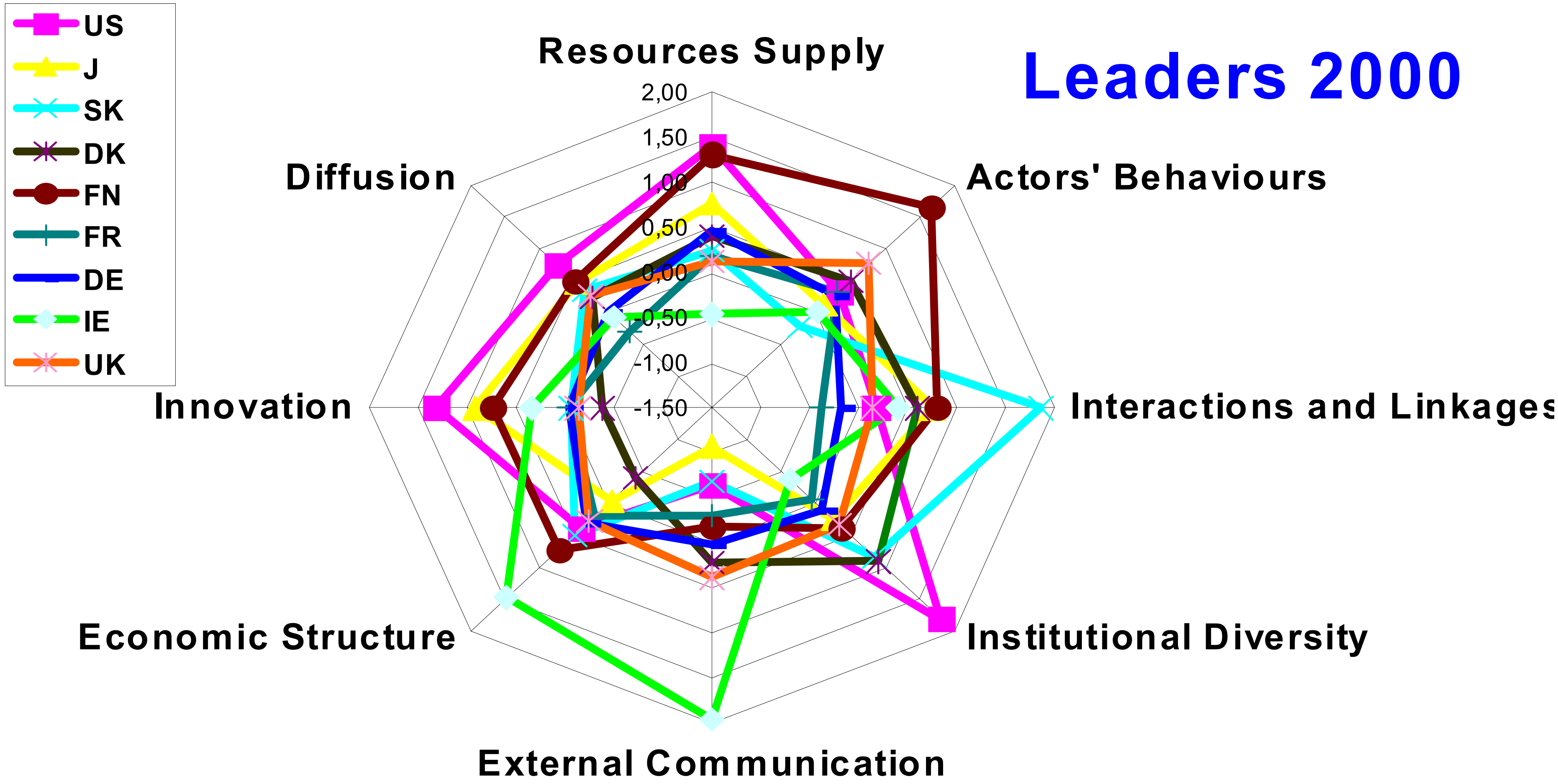
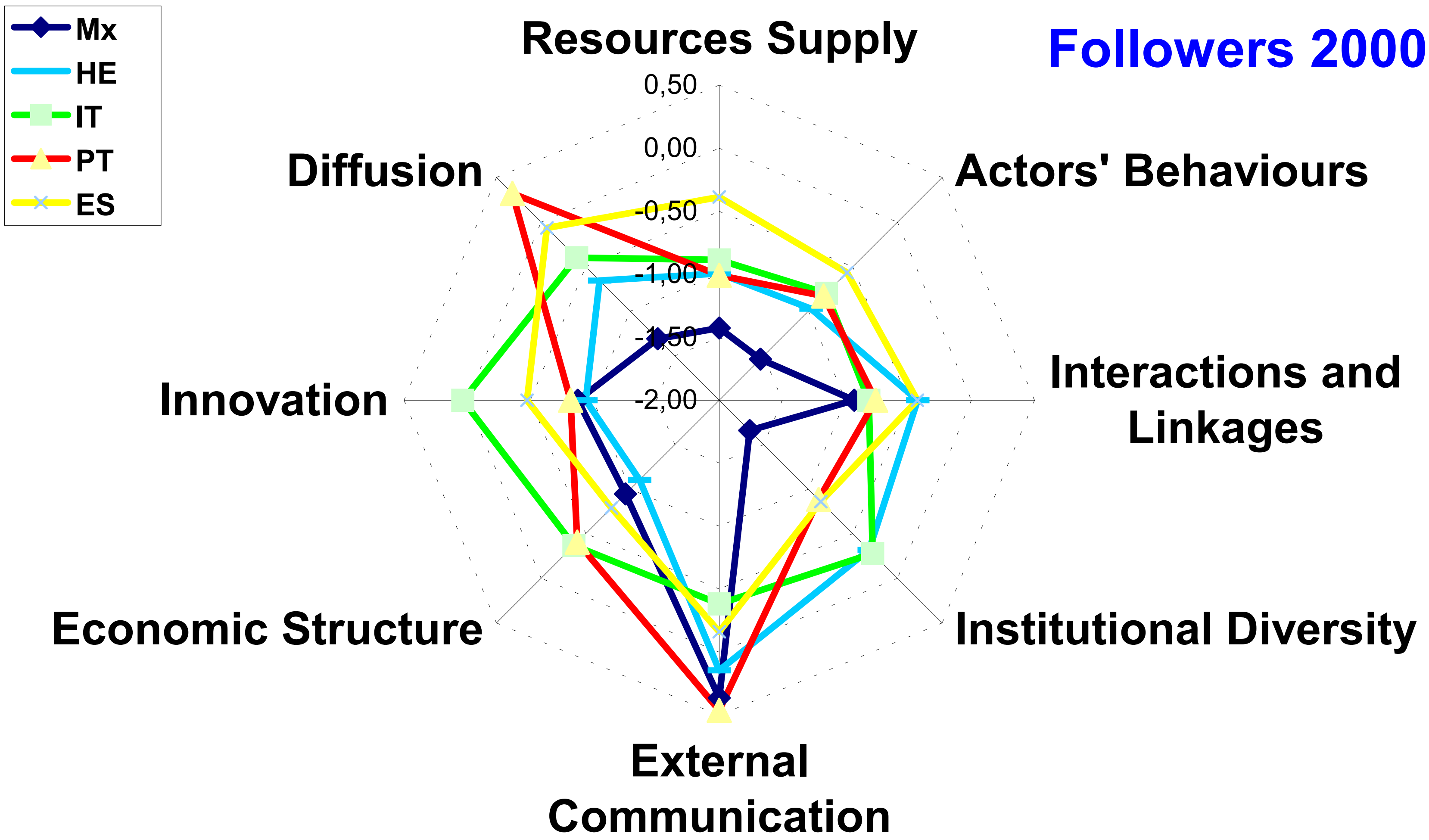

Leaders 2000
US
J
SK
DK
FN
FR
DE
IE
UK
Resources Supply
Actors' Behaviours
Interactions and Linkages
Institutional Diversity
External Communication
Economic Structure
Innovation
Diffusion
2,00
1,50
1,00
0,50
0,00
-0,50
-1,00
-1,50

**Figure 6**


Mx
HE
IT
PT
ES
Followers 2000
Resources Supply
Actors' Behaviours
Interactions and Linkages
Institutional Diversity
External Communication
Economic Structure
Innovation
Diffusion
0,50
0,00
-0,50
-1,00
-1,50
-2,00

To conclude this section we will turn to another aspect: how can we consider the evolution of NISs within the analytical and graphical framework that was put forward? As the composite indicators estimated for each year derive from a standardization procedure, the absolute values of the variables they are based on lose their specific meaning. In these circumstances we can not measure the growth (or eventual decline) from year 1 to year 2.[4]

Even so, a comparison is possible. For that, we can determine how the individual NISs evolved in relation to each year's average. In practical terms this translates into a comparison of each NIS relative size in both years, as indicated in table 4. In figures 7 to 9 we provide visual information respectively about a "expanding", a "stable" and a "contracting" NIS, being all these qualifications relative to the average trends.

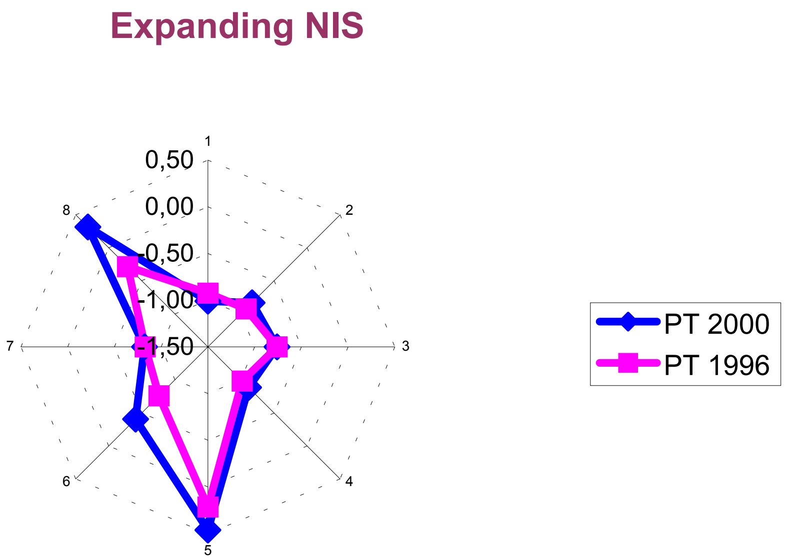
**Table 4 - NISs relative evolution**

| **2000-1996** | |
|---|---|
| Portugal | 0,12 |
| Denmark | 0,09 |
| Italy | 0,08 |
| Germany | 0,07 |
| Finland | 0,05 |
| South Korea | 0,02 |
| US | 0,01 |
| Greece | 0,01 |
| Spain | 0,00 |
| Japan | -0,02 |
| Mexico | -0,05 |
| France | -0,10 |
| UK | -0,15 |
| Ireland | -0,18 |

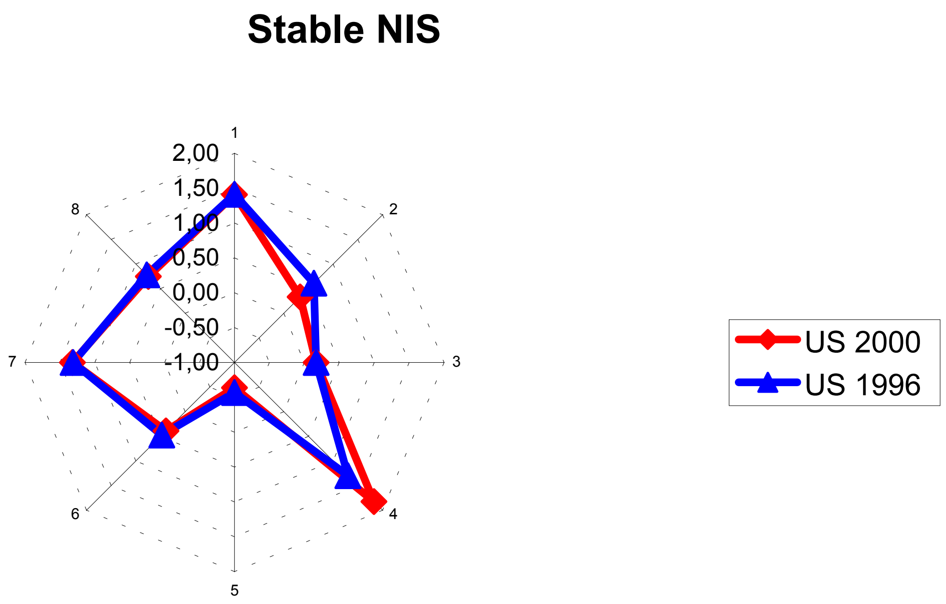
Note: This "evolution" indicator stems from the consideration of the distance between each NIS and the 14 countries' average in both 1996 and 2000. Specifically, in each year we divided the country's NIS size by the mean area value (11,3137085), and then we calculated the difference between both years' quotients. The countries with positive values are those that evolved at a higher speed that the average, while those with negative values are the ones that evolved at a lower speed.

[4] That would be possible if the standardization is carried out not for each specific year but for both years together. But that would introduce other requirements, namely the need for price indexes to deflate monetary values.

## Figure 7

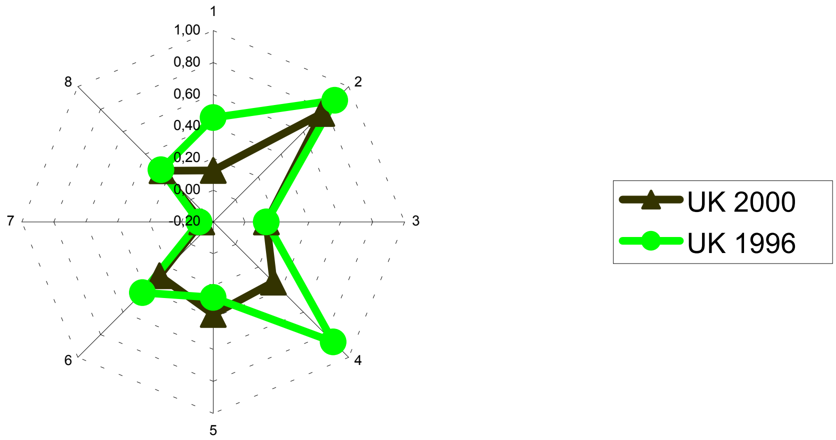



## Figure 8



# Figure 9

**Relativelly Contracting NIS**




**5. Concluding Remarks**

In the previous sections we have attempted to answer several questions that were put forward in the beginning. Those questions include: Is it possible to measure NISs? What specific technique may be used for that? Can we apply that technique both to the advanced and the catching up economies?

The exercise we carried out above in mapping NISs shows that positive replies can be given to those questions. The technique which was put forward, although simple in the steps it requires to produce the graphical representations and the quantitative indicators of NISs, shows a significant potential for both analytical and policy-making purposes.

In what regards the analytical value of the decomposition process that led us to an identification of eight major dimensions, we are aware that arguments can be put forward to criticize both those dimensions and the indicators that were used to illustrate them. It might be argued namely that our choices do not represent fairly the diversity of theorisations that have been produced on the subject. However, what is relevant in the process that was implemented, is not so much the choices that were undertaken in terms of the identified dimensions or selected indicators. What is relevant is the process itself, in the sense that by getting involved in it one is forced to be specific about what exactly is meant by "NIS" and also about the identification of its components, or aspects, that deserve to be analysed with greater attention. This process might therefore help the conceptual work on NISs to evolve further in the future, from elaborations which have essentially been qualitative in their nature to more precise definitions of "NIS" and its components.

In what concerns the practical policy-making dimension, the cartography of NISs that is produced through this method, together with the associated indicators, indisputably show high potential. In this respect, it is clear that our work is fully in line with the indications stemming from core research on innovation systems: «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). In the same vein, we must also recall the conclusions of a recent 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).

The tool that was developed in this paper fits well into the type of benchmarking and comparative analyses that have been sought in the literature on innovation systems. At the same time it avoids the oversimplification dangers that have been associated with much recent scoreboard exercises. In addition to that the fact that it helps in identifying clearly the weaker and stronger aspects of each NIS, and that it might also provide indications about NIS evolution and development over time, has policy-making value for both the advanced economies and the intermediate catching up countries.

To finalise we must say that besides eventual conceptual shortcomings, regarding the definition of the NIS dimensions etc., an aspect to be dealt with more thoroughly in the future concerns data quality and comprehensiveness.[5] As regards the results of the present exercise they shall be seen as strictly experimental. The summary measures we presented and the graphical depictions of NISs that were produced shall therefore be taken as merely indicative of what is actually happening in the 14 countries that were selected for analysis.

[5] The publication of CIS-3 results for European countries might help in this respect, even though similar data will still not exist for many other countries.

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