UNITED NATIONS UNIVERSITY

UNU-MERIT

Working Paper Series

#2007-027

National Systems of Innovations and the Role of Demand. A Cross Country Comparison

M. Abraham Garcia-Torres.

United Nations University - Maastricht Economic and social Research and training centre on Innovation and Technology
Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499, e-mail: info@merit.unu.edu, URL: http://www.merit.unu.edu

National Systems of Innovations and the Role of Demand. A Cross Country Comparison

M. Abraham Garcia-Torres[1].

September 2007

Abstract

This article focuses on the role of demand in the National System of Innovations: why it is so important, and how does it affect the dynamics of the system and the flow of inventions and innovations.
To study the evolutions and the dynamics of the different systems a series of composite indicators will be build up. In the paper it will be argued that the system of innovation can be defined by four different dimensions: Social and Human Capital, Knowledge Creation, Innovation capacity of the Supply and Innovation from the Demand.
The evolution of these dimensions is studied over a period of fifteen years and compared across fourteen European countries. This structure allows to study different dynamics, and evolution over time of different systems. The study highlights the weak links of the system, comparing each national system with the performance of the rest of the states members. The identification of the weakness and the evolution of the weakness over the time gives interesting policy conclusions.
The aim of the paper is also to contribute to the theory of composite indicators by offering a new approach to select, after carrying out a sensitivity analysis, the best indicator.

Keywords: National System of Innovations, Composite Indicators, Benchmarking, Demand.
JEL: O30, O38, O52, P46

UNU-MERIT Working Papers
ISSN 1871-9872

Maastricht Economic and social Research and training centre on Innovation and Technology, UNU-MERIT

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at the Centre to stimulate discussion on the issues raised.

[1] UNU-MERIT, Maastricht University.
P.O. Box 616, 6200 MD Maastricht
The Netherlands
Tel: +31 (0) 43 388 44 03
Fax: +31 (0) 43 388 49 05
email: garcia@merit.unu.edu

1 Introduction

National System of Innovations (NSI) is a broad concept which enjoys a growing popularity among scholars and policy makers. The popularity of this concept is due to its capacity to alleviate some of the difficulties related with technological change. To understand this success we have to look, on the one hand, to the recognition of knowledge as the main driver of a nation's wealth. On the other hand, we have to look to an opposition to simplistic ways of introducing technology in neoclassical growth models. The NSI, is more a systemic approach, which takes into account different interrelations among actors of the society namely: firms, consumers, universities, institutions...

Let us briefly comment two ideas related with this opposition to the simplistic view of technology in the neoclassical framework. First why demand is relevant on this systemic view, and second the ideas of complementarities among different factors of the economy as a key point to successful innovation processes. The relevance of demand in this systemic framework could be seen as a continuation of demand pull theories to explain innovation processes. In the early 70s, Schmookler (1971) argued that society is affecting trough market mechanism the allocation of economic resources dedicated to innovation, and therefore shaping the evolution of technological change. Rosenberg (1969) concentrates his argument in process innovation and he writes about demand for new techniques how they emerge and evolve. Many other arguments from the supply side were brought up as being relevant. And a debate known as demand pull versus supply push theories started. In a way the systemic view could be interpreted as an eclectic position to this debate, in which demand plays a role. In the words of Edquist :

> One consequence of the interdependent and non-linear view which characterizes the systems of innovation approach is that is natural also to bring in demand as a determinant of innovation (Edquist, 1997, p.21,)

The second idea we want to stress is the importance of complementarities. The tradition of economic research is based on trade offs. For example, someone chooses between saving and expending and depending on the decision, there is always some kind of trade offs that helps that person find an optimal solution. Expending too much give instantaneous satisfaction but it is risky for the future. So in this trade off the individual takes a decision. But in a way the NSI approach is trying to say something slightly different. This literature is saying that is not just a trade off between educating more the population and doing more research, the idea behind this approach is to say that these decisions complement each other. That they are complementary decisions. By having a more skilled population the output of R&D will be much more efficient. This paper is trying to define four important dimensions for the NSI. And it is trying to study the complementarities among these dimensions. Having done that, the paper present a way to detect in which dimension the system is weak. Talking about a weak dimension we mean a dimension that is not generating the expected complementary with the rest of them.

Under our point of view, still the role of demand has not been studied. It is recognized among scholars the role of human capital and knowledge to improve the production capacity of the country. But how is demand affected by these factors? Can he find some complementarities between knowledge and demand?. These are main concerns for this research.

The literature on NSI covers very different aspects and uses very different methodologies going from case studies to input-output tables. Recently a branch of the literature is moving toward a quantification of the system that permits comparisons between countries(Porter and Stern (2001),Furman et al. (2002), Chang and Shih (2005) and others). This chapter following that branch of the literature follows a quantitative approach. The quantification of the NSI is based on composite indicators. The main different with the rest of the studies is an explicit inclusion of the role of demand in the systems.

One of the contribution of this chapter is to bring some light into composite indicator methodology(for a discussion on the main issues concerning indicators see Nardo et al. (2005)). The main idea is that when researches try to build a composite indicator, many decisions concerning missing data, normalization and weighting techniques need to be taken. Those decisions affect the value of the final indicator. Despite the fact that a sensitivity analysis should be carried out, there is no clear answer as how to decide for the best indicator. A growing literature is covering this topic, and with the methodology we present a way to decide on the “best” way to build a composite indicator. We made this trough a technique that we call “minimizing the distance to median”.

The next section will make a selective review of literature based on the role of demand and quantification methods for NSI, section 3 will discuss the methodology and the analysis carried out in the frame of composite indicators, section 4 comments the results and some policy indications. And the last section of the chapter concludes.

2 Review of literature

To make a detailed review of all that has been said and written about national systems of innovation is beyond the scope of this chapter. For a detailed introduction to the history and different approach see for example Montobbio (2001) or Lundvall (2005). Instead this section will first review the role of demand in the NSI literature and afterward will comment on different attempts to quantify NSI.

2.1 The role of demand

In this section we will try to review what are the characteristics of demand that were important for different authors writing about the subject. More specifically where does demand play a relevant role in the concept of NSI, and why it is important in the argument. Some authors have focused their attention on the role of international demand, others in national demand and some of them argued that both are relevant. The unit of analysis is the country, therefore international demand will be demand of the rest of the world. The reasons how demand affects the system are very heterogeneous.

In one of the first article using the concept of NSI Freeman (1982), the role of *international demand* is present. One firms that innovates and successfully exports its innovation, enjoys an export monopoly that can exploited until imitators come into the market. The capacity of foreign demand to adjust faster than foreign supply is what allows this monopoly. These argument was introduced by Posner (1961). In the context of the international competition is the capacity of foreign demand to adapt quicker than supply of the foreign country, which for a time gives to that first mover country the competitiveness advantage. For example, Norway with mobiles phones and Italy. The Italian demand for mobiles adapt faster than Italian supply, this time lag gives Norway a competitive advantage. Sooner or later one might expect this monopoly to be erased by imitation. Posner find several arguments for this lag to continue on time. For example he says that at the beginning is a new product what generates this competitive advantage, in an international environment, but is the sequence of future process innovation link with this new product that allow to hold this international leadership for a long period. It is the **time lag** between the international demand and the national supply what allows the country to be more competitive. The time lag effect was further developed in the context of technical change and international trade (see for example Hufbauer (1970) or more general Dosi et al. (1990)). However since the focus of these research is the role of demand and the NSI, analysis of these theories is out of the scope of this study.

A different perspective is taken by Dalum (1992) when he is looking at the different export specialization patterns of 21 OCDE countries and how this export specialization affects to the performance of the NSI. Implicitly he seems to give international demand a higher weight than to national one, and tries to explain why different systems are arriving to different specialization patterns within a sectoral distribution of exports. Even though all countries have access to international trade, they specialize in different sectors. The reason for this specialization maybe historical or cultural. In this case international demand plays a role of **specialization** of the national capacity.

The recognition of a different segment of the demand can be the key factor in understanding international competition. In other words the finding of a niche withing the demand. In this case, we will argue that the study of the international demand is used as a source of **information**. A recognition of international new needs allows the country to take and advantage, it could be through the creation of a new good, or a new niche withing and existing demand. Perez (1985, 1988) is suggesting that the way for successful innovations goes through thinking about the new technological paradigm and the domestic demand. Used the information given by the domestic demand to adjust the new paradigm into the necessities of the household . For Porter it can be so important as to leapfrog another country. He gives the example of the competition of America versus Japan in copier machine industry. The Japanese discovered a new segment of demand, small machines, and they develop a new strategy to approach the buyer. (Porter, 1990, p. 36).

To summarize what it has been said, we found three main roles of international demand. The international demand is used as a source of information from were to identify new needs, it affects to sectoral specialization of the country and since it adjusts faster than international supply, during this time lag allows the country to enjoy monopoly rents. However important the international demand is, in this chapter it will play a marginal role.We will be using composite indicator and the measurement for the activity of international demand in the country are really scarce. So they will be left aside for future research. Instead we will focus on the role of national demand for which we find more detail information.

Some authors have centered their attention on *national demand* when they were trying to explain differences in performance across countries. The fact that a nation anticipates in its own needs the need of the rest of the world , can be an explanation for that nation to be a first mover into some industry. (Porter, 1990, p.98). This argument seems to explain why a country can enjoy the monopoly rents explained previously by Freeman (1982). Is the **time lag** of national needs versus the rest of the world that explains the superior national performance.

The role of **specialization** due to national demand is pointed by Freeman (1995) and differences in demand as one of the reasons against globalization. He argues that the differences in some industries might not be important but in some others they are. There are some national needs that under his point of view will never be satisfied by international supply. He highlights climate differences that affect the performance of machines, instruments, materials... and also cultural aspects that can not be ignored without consequences in areas as food, clothing and personal services. For example take two firms producing pizzas to take away, one Italian and one American. If we are looking at Italy it is more likely that the Italian one is more specialized in national tastes compared to the American firm

The **information** capacity of national demand is recognized as a key factor, for various reasons. Lundvall (1992) points to the relations between users and producers. These strong links help the producer to meet the needs of the different users. Out of these links the producer can find new ideas to either produce something new or improve her design. Von Hippel goes one step further, and attribute all the innovation process, in some specific areas to what he called "lead user"(von Hippel (1986), von Hippel (1988)). This idea seems to be also important for Porter, when he says that sophisticated and demanding buyers allow firms to increase the quality of the product. Although more that information seems to be that demand helps national **capacity building** power.(Porter, 1990, p.89). He is also highlighting the fact that a number of independent buyers help to **increase variation**, which seems to be a main concern for many evolutionary economists. The same idea, but always from the supply side, is met by Metcalfe (1995).

A stream of the literature has contemplated simultaneous *national and international* demand dynamics as a possible explanations to differences in nations capacity. Fagerberg (1992) is centered on testing the home market hypothesis. A strong home market means that it will allow the producer to grow faster in the production patterns, and make a strong competing national sector in the international market. The role of demand is **information** about the evolution of consumer needs, plus the **capacity building** that this demand has to increase the international competitiveness of the supply. Capacity building issue is also discussed by Freeman (2002) who points out that even after the Second World War, in the research organized by Europe to study productivity gaps with USA, the size of the domestic market is always acknowledged as one reason for this gap. Not only the size of demand but also its growth seems to be important. For Porter is even more relevant the growth of domestic demand. But Porter also points out that this advantage, big size of the domestic market, has been contradictory and for some countries a small demand has been found as a reason for pushing the competition in the international market. Porter comments that independently of the size of the market or the growth of demand, an early saturation of the domestic demand must be an explanation of internationalization of sales.

An interesting point regarding demand is raised when the public sector is considered as a determinant consumer. It is determinant in the sense of the proportion of consumption that it does in the economy. Gregersen (1992) centers her attention on the public sector as a huge consumer, thereby introducing the capacity of the government to affect the innovative process from the demand side. The same point is met by Edquist (1995), analyzing the role of the government as a sophisticated user, and by Malerba (2004) when he recognized that the demand is not one homogeneous consumer but composed of very heterogeneous consumers, one of them being the public sector. This way of thinking is very much connected to another branch of the literature military R&D, where the public sector is the main determinant and consumer.

At this moment one could wonder if demand has not been sufficiently analyzed in the context of NSI. But in my view there are several roles that have not been studied by this literature. Mainly three of them:

- The importance of habit formation. If one is thinking of innovations as one of the main drivers of the growth of the economy, it is impossible to leave aside this point. Is not just the fact that we need to invent something, but something that is useful in the long run is what allows an innovation to affect the growth of the country. There is a branch of the literature that have recognized some value to this problem for a long time (see for example Duesenberry (1949), Pollak (1970), Ryder and Heal (1973) and Scitosvky (1977)). But it is not until recently that there is a group of economists worried with the habit formation hypothesis and growth: Carroll et al. (1997), Alonso-Carrera et al. (2004), Alvarez-Cuadrado et al. (2004), Carroll et al. (1997) and Fuhrer (2000).
- The causality of growth to savings. Against the formal view that more savings generate more growth, the introduction of demand gives an argument to reverse the causality. The neoclassical way of understanding growth is through savings. In this orthodox framework more savings always mean more investment, and therefore more capacity to acquired new technologies, which is translated into more output. Again this argument is biased toward supply. Once we introduce demand, there is room for explaining a different causality. More consumption generates more growth and more savings. If we take this idea to a technological change framework, nobody will argue against the idea that an environment with an active demand will favor the appearance of innovations. An interesting empirical work trying to prove this reverse causality has been presented by Carroll and Weil (1994) and Carroll et al. (2000).
- Marketing expenditures. The idea that marketing is important for innovation has been pointed out by many scholars; as an example we have Freeman (1995). To be able to understand why the effort a nation makes in marketing is a determinant of innovation we have to understand how marketing expenditures affect a single consumer. Taking away the idea that preferences are constant (MAKE A REFERECE

TO CHAPTER TWO) it is possible to study how marketing affect the preferences. Once the individual is offered two substitutable equivalent options is normal that the one, in which a higher marketing effort is done, is higher probability chosen. If we assume that growth can be caused by an increase in consumption, a higher consumption pattern will be followed by the nation in which the marketing expenditures are superior. The relation between growth and marketing expenditures has been analyzed by Benhabib and Bisin (2000).

Having reviewed the different roles of demand in the NSI literature. In the next subsection we will have a look at the effort that in research is being made in order to quantify different characteristics of the systems. The main goal of this quantification the simplicity of making comparisons among national performance.

2.2 Attempts to quantify National Systems of Innovation

Although NSI was initially a qualitative approach to innovation, as has been argued by Godhino et al. (2005), several factors allow us to make a quantification of the NSI, that were impossible when the concept was born. An important generation of indices appears after the publication of the Oslo Manual. Several new indicators have been created either by EUROSTAT or OECD statistical offices.

The first step before trying to quantify a NSI is to explain which dimensions of the system should be taken in consideration by the analysis. Already Lundvall in 1992, argues that there are five interesting dimensions that any study considering this issue should analyze: Internal organization of the firms; inter firm relationships; the role of the public sector; institutional set-up of the financial sector; and R&D intensity and organization. The same five dimensions are used by Montobbio (2000), although recognizing that not only the internal organization of the firm is important, but also the vertical links of the firm with clients and suppliers. Making slight variations to the original division by Lundvall, avoiding the internal organization of the firms, and studying the regulations in the sector instead, Kaiser and Prange (2004) analyze these dimensions to understand the German biotechnology sector.Dang Nguyen and Jolles (2005) take the division as stated by Montobbio and add two new ones: social cohesion and access to ICT. A different approach is taken by Furman et al. (2002) and by Porter and Stern (2001). They propose to look at three dimensions: Common innovation infrastructure, National Cluster Conditions, and the linkages between these two previous ones. Although agreeing on the same number, Nasierowski and Arcelus (1999) propose to look at the inputs of innovations, at the outputs and the moderators in between the two. Godhino et al. (2005) follow this research, but looking also at the preconditions for innovation, the moderators are renamed as structural organization. A closer division is made by Liu and White (2001). They explain that their division as coming out of a detailed study of the literature concerning technical change. This is relevant for us, because these are the dimensions that fit better with our research. They propose to take into consideration: research, implementation, end-use, linkage and education.

Once the different dimensions highlighted by the literature have been discussed, the next step will be to deep into the different techniques and methodologies used for the quantified comparisons. A first group could be those studies that build composite indicators: Porter and Stern (2001) use regression techniques to build up a composite indicator that measures the national innovative capacity. The countries are ranked according to this index. In line with this research is the work done by Furman et al. (2002), but they use the composite indicator to run regressions on TFP. They were trying to explain what is the contribution of each index in the creation of innovations. Among their concerns is the intention to make a link between the endogenous growth literature and NSI. Dang Nguyen and Jolles (2005) work with eleven variables, that in a first step are divided along 7 dimensions, after which they use a principal component factor analysis to reduce them to two principal components. They study the dynamics of the countries based in these two factors. Godhino et al. (2005) used 29 variables, to make 4 dimensions with the indicators. They use these indicators to perform a cluster analysis. Based on the results they propose a taxonomy of NSI.

Nasierowski and Arcelus (1999) proceed in a different way to study the NSI. They are using a set of eleven indices, that they classify as inputs, moderators and outputs. Afterward they proceed with different settings of a system of simultaneous equations, to see what is the best relation to the linkages among the inputs, moderators and outputs of innovations. Chang and Shih (2005) used an input-output matrix to study R&D intersectoral relations, and diffusion of innovations. They compared the systems of Taiwan and China. An interesting point is raised by Coombs et al. (1996) when suggesting a new way of accessing innovation performance, counting innovations published in specialized journals. More oriented toward the business literature, Chiesa and Manzini (1998) classify the NSI according to the different strategies that firms use when they decide to innovate.

3 Methodology to construct composite indicators

Most of the discussion that follows is based on a bench market analysis, using composite indicators. In this section we want to analyze the effects choosing different techniques for building an index on the value of the final index. Since this is the principal tool use in the discussion, we consider important study this techniques. We are interested in studying four dimensions of the system. As we argued in the section 1 our study of the system is very similar to Liu and White (2001). Four of the five dimension that they are using have an equivalent with one of our dimensions. For each dimension we are using a set of three variables. In this section we will discuss the way in which we have built the composite indicator.

In total we have the twelve variables, presented in Table 1. Initially we want to make a composite indicator for each dimension. We are studying fourteen European countries: Austria, Belgium, Germany, Denmark, Spain, Finland, France, Greece, Ireland, Italy, Netherlands, Portugal, Sweden, and the United Kingdom. These are all the countries of the EU-15 group, without Luxembourg. This country have been deleted from the sample due to the quality of the statistics provided by its statistical office. We are interested in the evolution of the dynamics of the system, therefore we try to get the variables for as many years as possible. The period of the study initially goes from 1993 to 2003 both years are included . For each variable we have a panel data structure of 14 countries times 11 years. In this situation at the maximum, assuming no missing values, we will have per variable a total of 154 data.

DIMENSION	VARIABLES	SOURCES
Human Capital	% of work pop. with tertiary education	EUROSTAT
	Life Long Learning	EUROSTAT
	Total Expenditures in Education (as % GDP)	OCDE
Creation of Knowledge	Public Expenditure R&D (as % GDP).	EUROSTAT
	Number of scientific publications (as % pop)	CORDIS
	Internet users per capita.	WTI
Innovation Capacity of Supply	BERD(as % GDP)	EUROSTAT
	labor productivity	EUROSTAT
	high tech exports over total exports	EUROSTAT
Innovation Capacity of Demand	Total expenditures on Mobiles per capita.	WTI
	Consumption (as % GDP)	WDI
	Marketing expenditures (as % GDP)	EUROSTAT

Table 1: Dimensions and variables

For each dimension we have a composite indicator made out of three variables. To discuss the issues raised from composite indicators techniques we focus our attention in one year and one country in one dimension. For example let us talk about Austria in 1993 and in the dimension of human capital. For this point we have three variables which are: proportion of population working with tertiary education in 1993; Life long learning and expenditures in education for this year. The reasons why we choose these variables instead of others will be discussed in the next section, when we introduce the economic sense of each dimension.

Now if we want to built the indicator we have to discuss at least three steps: imputation of missing values, normalization of the data and weighting techniques. We follow some of the ideas suggested by the Handbook of Composite Indicators, published by the OECD. We are interested in comparing how countries performs, but not simply in a ranking of countries that changes for every year. Instead we are looking for an indicator that varies within a meaningful range. We found relevant these methodologies for each step:

- For the imputation of missing values: no imputation, mean year imputation and regression imputation.
- When normalizing the data : distance to the mean, standardization and rescaling.
- Concerning weights: Equal weights, Factor Analysis (FA) based on correlation matrix, FA based on variance covariance matrix, and the benefit of the doubt.

With three imputation thechniques, three possible normalizations and four methods for setting weights there are 36 possible outputs for each year and each country. Now, the manual from the OCDE tells us that we should do all these permutations just by way of knowing what are the possible outcomes. One possible way to choose "the best" indicator would be to calculate the mean over these 36 outputs, and choose that one that it is closer to the mean. But with so much variation in the process, the distribution of the outcomes could be very skewed, and if this is the case it would be better to use the median instead of the mean.

In case the distribution is symmetric, the values of the median and the mean will be close. Which means that using one or the other will not affect our results. But in case of very skewed distributions, like the one on the right side of figure 1, the median might capture better our idea of an stable indicator. The idea is that we would like to choose the best method to build the composite indicator, the one that is least affected by changes in the procedure. Or in other words the methods that remains closer to the median. Our position is not to satisfy the government of a country with our outcome, but to find the most effective way to explain relations between the variables, and the different outcomes of the national system of innovation of the countries. Therefore for us a procedure like the benefit of the doubt will not be useful, unless this procedure is most stable one. What we are looking for is a way to take into account all possible variations in the indicators due to the different building techniques and minimized them.

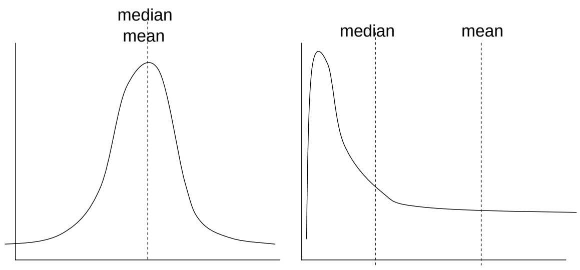

Figure 1: Mean and Median: Symmetric and skewed distributions

The idea of this chapter is to introduce a methodology to choose for the most consistent way of producing an composite indicator. We argue that the distance to the median can help us to understand what is the effect of each step in the final outcome. We generate all possible outcomes numerically, calculate the median, and calculate the distance of each method to the median. One possible way to proceed could be to choose the minimal distance to the median indicator. Which such a way of choosing a procedure we know that this is the most stable. This “best” method takes into consideration all possible variations and it has minimized all of them. This indicator when compared to the rest is more stable, and less sensible to variations in procedures of construction.

Once it is in mind what we want to do we will explain the reasons behind every step. Holding in mind that we want to obtain the best indicator by minimizing distance to the median.

3.1 Imputation

Imputation deals with decisions concerning treatment of missing values. Three options are considered. We have a panel structure of the data, the missing values do not depend on the variable of interest therefore they are missing completely at random (MCAR)[1], under the classification given by the OCDE. Due to the structure of the data, we have three imputation options:

1. No imputation of missing values. The blank spaces are left empty.

[1]see discussion of Nardo et al. (2005)

2. Mean year imputation. We fill in the values of the years in between two real data with the mean value, leaving the rest as blanks. So if we have for example the data for Austria 1994 and 1996, we will calculate the value for Austria 1995 as the mean value of the indicator, but still leaving empty Austria 1993, since there were no data to calculate the mean value.

3. Regression imputation. We calculate the trend of the data over the years for each country, an impute all the missing value. This system of imputation leave us with the tables completed.

It is important to know that if we have missing values, that affect the total number of outputs per indicator that we have for this year. Imagine for example that the value for Austria is missing for the year 1995, but we have it for 1994 and 1996. Using the first imputation methods, it will stay empty, but using the second and the third we will have an outcome. In the next steps if we have no data we can not construct the indicators. So this will affect to the total number of outcomes per year.

3.2 Normalization

The variables that compose each indicator vary within very different ranges. So before being able to add them up we need to choose some normalization process. In such a way we homogenized the range of the variables.

If we take into account different normalization methods that are suitable for our purposes, we initially consider:

1. Distance to the European mean by year. The range of the normalization ranges form 0 to $+\infty$

$$x_{it}^N = \frac{x_{it}}{EU_t}$$

2. Standardization (or z-scores). We do this year by year in a cross section of the countries. The range in this case goes from $-\infty$ to $+\infty$

$$x_{it}^N = \frac{x_{it} - \overline{EU_t}}{\sigma_{EUt}}$$

3. Rescaling. This system gives 0 to the minimum value, and 1 to the maximum.

$$x_{it}^N = \frac{x_{it} - \min_{it}(x_{it})}{\max_{it}(x_{it}) - \min_{it}(x_{it})}$$

Regarding the normalization process, and thinking about how each of them could perform in relation with their proximity to the median. It seems logical that the z-scored normalization will produce more variation when compare with the rest of the procedures. The two other normalization processes produce a range of values smaller and therefore more highly probable to be close to the median than the z-scores. But it could be still interesting that this normalization process gives us something relevant, this is the reason why we rescaled the values of the z-score and bring then back to a scale 0 to +infinity, giving to the mean the value 1:

If we call z_i the value of the standardization process

$$z_{it}^{N} = \frac{x_{it} - \overline{EU_t}}{\sigma_{EUt}}$$

we rescaled then according to this formula:

$$r_{it}^{N} = \frac{z_{it} - \overline{Minz_{it}}}{\overline{Minz_{it}}}$$

3.3 Weighting

Any scalar indicator that combines several components must somehow weight those inputs relative to each other. Here there are in principle four reasonable options:

1. Equal weight to the three variables. In other words we are calculating an arithmetic mean.

2. Factor analysis based on the correlation matrix. To get these weights we work with the correlation matrix. We take the tree values of each variable for every year and calculate the correlation matrix of these three values. We calculate the eigenvalues of the correlation matrix. Take the weights based on these eigenvalues as indicated by the OCDE.

3. Factor analysis based on the variance-correlation matrix. The procedure is similar to the previous one, but instead of using the correlation matrix we are using the covariance matrix, so we are giving weights that are based on the actual value of the variance instead of the correlation coefficients.

4. The benefit of the doubt approach (BOA). The idea behind this technique it is to choose the weights that maximizes the value of the indicator. The best way to maximize the output of the indicator is to give the weight 1 to the maximum value of the three normalized variables. But since we also want a composite indicator, in which the three values are present we make a constrained maximization. The OCDE report is using the fix weight values 0.5, 0.40 and 0.1; as the restriction of the maximization. With these fixed weights we take the normalized variable that is scoring highest and give to it a weight of 0.5, the second best we give 0.4 and the lowest variable has a weight of 0.1. The

idea of this maximization process is to get a better score than with the other weighting systems. But a closer look to the weights of the factor analysis, give us values which were close to 0.8, 0.15, 0.05 and in some stream cases even higher that these ones. For these reasons the values that we use are 0.75, 0.2, 0.05. This three values of the restrictions assure us that the scores of the indicators will be maximum in a big majority of the cases. And still using a reasonable presence of the three ingredients of the composite indicator. For a more detailed discussion of the advantages of this approach see Saisana et al. (2005), Bowen and Moesen (2005) and Cherchye et al. (2004)

In all the cases if any of the three indices were missing we do not calculate the indicator. We proceed like this because we are already taking into account this missing values by the imputations methods. So the average (equal weights) has been only calculated if the three values were not missing. This seems to be, under our point of view, the most consistent way to proceed with the analysis. In the case of equal weights one possible alternative will be to recalculate the weights, as to get an arithmetic mean. For example, if the weights when we have three indicators is 1/3 for each, but we are missing one, we could get the index using with the remaining information the weight 1/2. However to be consistent in the analysis we should follow a similar approach, when we are using FA techniques to recalculate the weights, and in this case it confuses too much the outcomes. Therefore to be consistent we have only calculated the output when the three variables have no missing values.

As related to the way in which we proceed with the benefit of the doubt approach, we have to say that this methods is built to get the best output. If we think about the effect that the inclusion of the benefit of the doubt is inducing in our analysis, especially on the median. Probably by generating so many benefit-of-the-doubt indicators we are upward biasing our median. To avoid this effect we include in the analysis the opposite of BOD, with the same weights, we made the country score the minimum value.

3.4 Evaluation of performance based on the distance to the median

In our uncertainty analysis we are taking three cases for imputing the data, four normalization procedures and five weighting techniques. Because we have add one normalization process and one weighting techniques to the OCDE manual, we go from 36 to a maximun of 60 different outcomes for every country for every year.

If we are missing data the minimum number of outcomes will be 20. This will be the case in which only through regression imputation we have information for this point. This information with four normalizations and 5 possible weights systems gives 20 points.

Every possible outcome will be determine by a combination of table 2. If we are talking about indicator 311, it will mean that we used regression imputation, the normalization procedure that we have used is distance to the European mean, and we are using no weights.

PROCEDURE		TECHNIQUE
Imputation	1	No imputation
	2	Mean imputation
	3	Regression imputation
Normalization	1	Distance to the European Mean
	2	Standardization
	3	Re-scaling
	4	Standardization and rescaling
Weighting	1	No weights
	2	FA weights correlation matrix
	3	FA weights covariance matrix
	4	Benefit Of the Doubt
	5	Opposite Benefit Of the Doubt

Table 2: Different indicators outcomes

Every country in each year has either 20, 40 or 60 outcomes. For every year we calculate the median, and calculated for every year the distance to the median with the following formula:

$$d_{it}^{c} = \sqrt{(x_{it}^{c} - Median_{t}^{c})^2}$$

This has been done in a country and year base. This distance is calculated for each point. Now we sum up this values according to methods, and we could see which is the methods that behaves in a more stable way. We could do this for each of the four dimensions. Or we could do it as to come with one single method that works best for all dimensions. We carried out both alternatives and the results are the same. Therefore we present the general case in which sum up for all four dimensions.

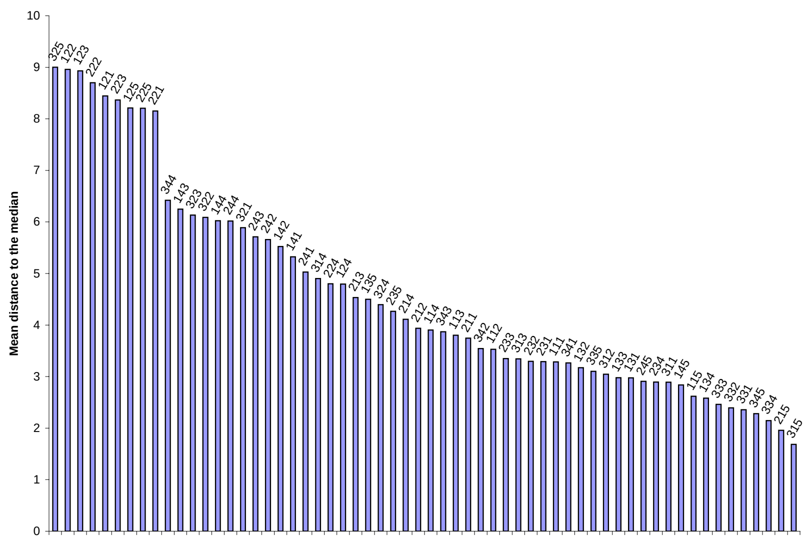

Figure 2: Results of the mean distance to median approach

The results of the analysis are presented in descending order in figure 2. Each column is the average distance to the median that each methods has. We could just have a look at this graphs and choose the one that has a minimal score. In this case we will choose the procedure 315, that translated with table 2 means: regression imputation, no weights, and Opposite to BOD approach or minimal weights.

But before taking a quick decision we think it is worthy to group every outcome according with the different steps that we have taken. The first point is to have a look at how well the different imputation methods. The results are plotted in figure 3. They have been plotted according to the three different imputations methods, then we have ordered them in a descending order. The line behind the bars, is the average performance according to the different groups. A first look at the data already make us see that the regression imputation is the technique that on average, taking into account all the uncertainty coming from the rest of the procedures scores closer to the median.

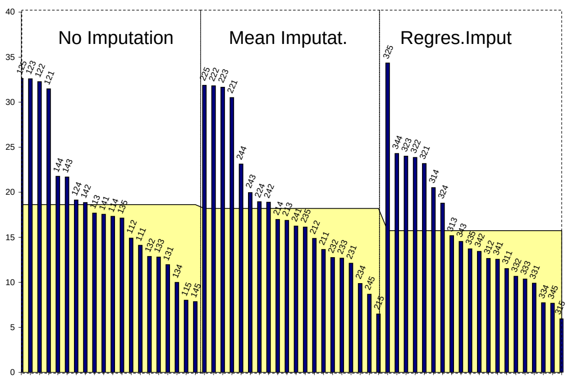

Figure 3: Inputation techniques

We do the same for the different normalization techniques. This information is presented in figure 4. In this case it is important to remember in which range the values of the different techniques oscillate. The distance to the mean changes in theory between 0 and $+\infty$, giving 1 to the mean value. But in reality there is no indicator scoring zero under this normalization technique. And it is hard that any country scores the double of the mean. In reality as an approach this method varies within the range 0.3-2. The standardization varies withing a range of $-\infty$ and $+\infty$. And in the implementation it changes from -3.5 to 3.5. This might be one of the reasons why the average distance to the mean is so big. This also explain why rescaling seems to score so well, because the maximum variation lies within the range 0-1. The extra normalization process that we introduce in the analysis, ranges withing 0- $+\infty$. This makes it comparable to the distance to the mean process, because the ranges are similar, but the dispersion in the second case is bigger which is due to the fact that is coming from the standardization process. When we choose this last method, we took the output of the standardization ranging from $[-\infty$ and $+\infty]$ and rescale to $[0+ +\infty]$ giving the mean the value 1. Probably if we have rescaled to [0,1] the average bahaviour will have remained more constant to the median value.

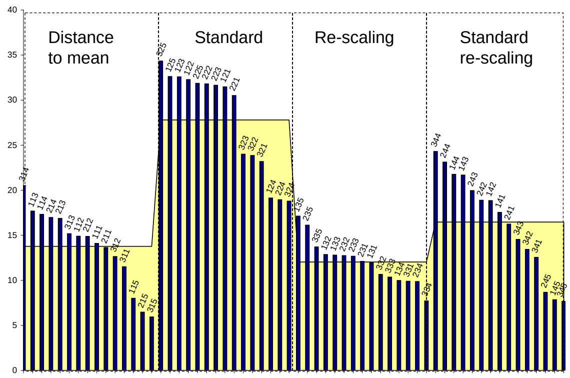

Figure 4: Normalization

Thinking about the best normalization process, we could either choose the distance to the mean, or rescaling. But since we want to have some economic results, and study the implications for each system, it is more intuitive to work with the distance to the mean. It makes our analysis easier to explain.

A first look at figure 5 seems to put the different weighting systems, in a very similar positions. It is interesting to have a look at the artificial minimum weight system. The procedures 325,125 and 225 have a very high distance to the median, this is due to the fact that we are using a standardization process, which give us very high negative values, and the through the weighting system making the indicator score low. So probably this indicators are very far from the median. With the BOD approach, or maximum weight the behavior seems to be more moderate. The weights that we used were 0.75, 0.15 and 0.05. A decrease of this weights, using for example the limits to the weights suggested by the OCDE 0.5, 0.4 and 0.1 will probably reduce the mean behavior of this procedure. The simple average, or no weighting systems, seems to perform equally better than the rest. So for simplicity we choose this one. Also because it is much easier to proceed with the interpretation of the composite indicator.

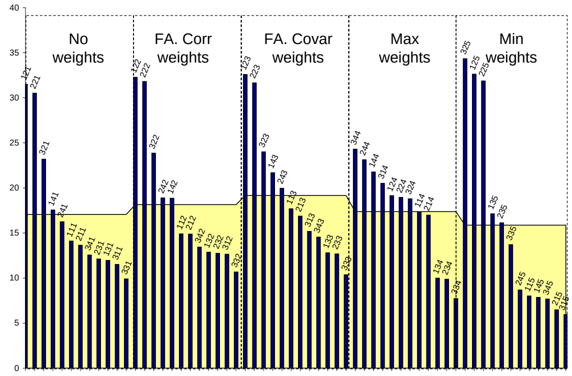

Figure 5: Weighting Techniques

The composite indicator that we will be using for the rest of the analysis, due to this discussion will be 311: imputation of missing values through regression, distance to the mean normalization and equal weights for all the variable of our composite indicator.

4 Economic implication of the indicators

In order to turn back to the economic implication of these indicators, we will like first to reflect about what innovation means for the knowledge society. An innovation is nothing else than a creation of value out of one idea. If the idea is associated with the concept invention, therefore the innovation would be the economic value of such an invention. For the value to be created the new ideas have to be connected to the market through new goods or services, or through better ways to producing, marketing and delivering the goods. The final acceptance of the value of the innovation comes from the market, the interaction between two forces: demand and supply. We are going to study the links between the different aspects that we consider essential for a well functioning of a NSI. The idea of this paper is to compare this whole process for each country in the sample.

Knowledge seems to be the key word in all this process, and therefore we speak of a knowledge economy, as being the central input in the production of wealth. Generally accepted among economists is the idea that there are two forms of knowledge: embodied or tacit and codified or disembodied. Embodied knowledge is present in people, in their experience, and it is hard to transmit. Codified knowledge is presented in a form that another person can understand it. We will be looking at the relation between these two forms of knowledge: embodied in human capital and disembodied. We are trying to see the relations between these two dimensions, and how these two dimensions are affecting the generation of value in interaction between supply and demand.

We can have a more detailed view at how do we built the indicators, and why do we choose each of the variables in the composite indicators. The four dimensions are:

- Human Capital: The quality and quantity of human capital are fundamental for innovation system performance. It is fundamental in the sense that it is through human capital that knowledge can be transformed into inventions and latter into innovations: new processes and products. We are interested not only in the capacity that a country has to educate its population, but also in the spread the existing knowledge. Therefore we use as ingredients for this composite indicator, as an input of the national effort we use the expenditures in education as a proportion of GDP. As an output variable we use the percentage of working population with tertiary education, as an indicator for how well the population is educated, not saying that tertiary education is the only one relevant, but taking it as the tip of the iceberg. And the third component is proportion of working population which is involved in live long learning as a way to keep updated with the evolving knowledge.

- Knowledge: We would like to asses the effort realized by the nation to push forward the frontier of knowledge. Also how much is the national capacity to use this knowledge. The three variables that we consider here are public expenditure on R&D, as an indication of the national capacity to push knowledge in a more basic knowledge way than the Business R&D where we expect a more profit oriented intention; the number of scientific publications per capita, this is an output indicator of knowledge performance of how well the resources are used to produce codified knowledge; and the last variable is the number of internet users per capita. This last indicator is a way to see how quickly the knowledge of country diffuses. It is also not just scientific knowledge, but also the information about new products that is diffused more rapidly via the internet.[2]

- Supply Innovation Capacity: What we want to understand out of this dimension is the national capacity to use human capital and the ex-

[2] Eurostat is producing a new indicator that is proportion of internet users that is used the net to find out characteristics of new products or services. This indicator will be much more accurate, but the time period is very short and hard to get the information we need for our interests. Both indicators were highly correlated

isting knowledge to produce in a more efficient way. We consider here labor productivity index, thinking of the reduction of cost (increase in productivity index) as a result of the capacity of the nation to take advantage of human capital and knowledge; business R&D, as a private effort to generate the specific knowledge that the production needs; and finally the proportion of hight tech exports, as a measure of how competitive in its exports capacity is the specific country.

- Demand Innovation Capacity:This is a parallel concept to the previous one: we are interested in the capacity that knowledge and human capital has to increment the sophistication and the needs of the nation. We try to asses the impact of a more qualified society and with more access to an increasing stock of knowledge to create a more favorable environment for the creation of innovations. To compare this dimension across countries we use the total expenditures in mobile phones per capita, the idea is to understand how the habit of a new innovation varies across countries. National marketing expenditures as a percentage of GDP, as a national effort to diffuse new products, and the proportion of GDP that goes to final consumption, the intuition being that a nation more ready to spend is more likely to generate new products.

The first step that we take is to study the relation among the four indicators. To do this we have plotted the four dimensions in the figure 6. We pool all the data together for all years and countries and plot in a scatter graph the four dimensions against each other, adding a linear regression line. A first look at the graph will quickly show that the first three dimensions of the NSI, are highly correlated, while the indicator on demand innovation capacity is not. Let's review briefly the theories behind these relations.

The first square shows us the relationship between the human capital of the nation and the capacity to increase the knowledge, it shows a very strong positive relation between the two indicators. Which basically is supported by the idea that a higher educated population will have a higher possibility to push the frontier of knowledge. The next square shows the relation between human capital and the capacity that the working population has to improve the productive capacity of the country. We can see that here the relation is also quite strongly positive. If we look at the relation between knowledge and supply, it can also be seen that the relation is positive but less strong than the previous one. So even though we find a positive relation between the increase in knowledge and the capacity to improve productivity, taking into account the previous relations, it seems to be stronger through human capital. We can see this stronger relationship from the slope of the regression lines, which is higher for human capital than for knowledge. It is possible that the impact of knowledge runs through the

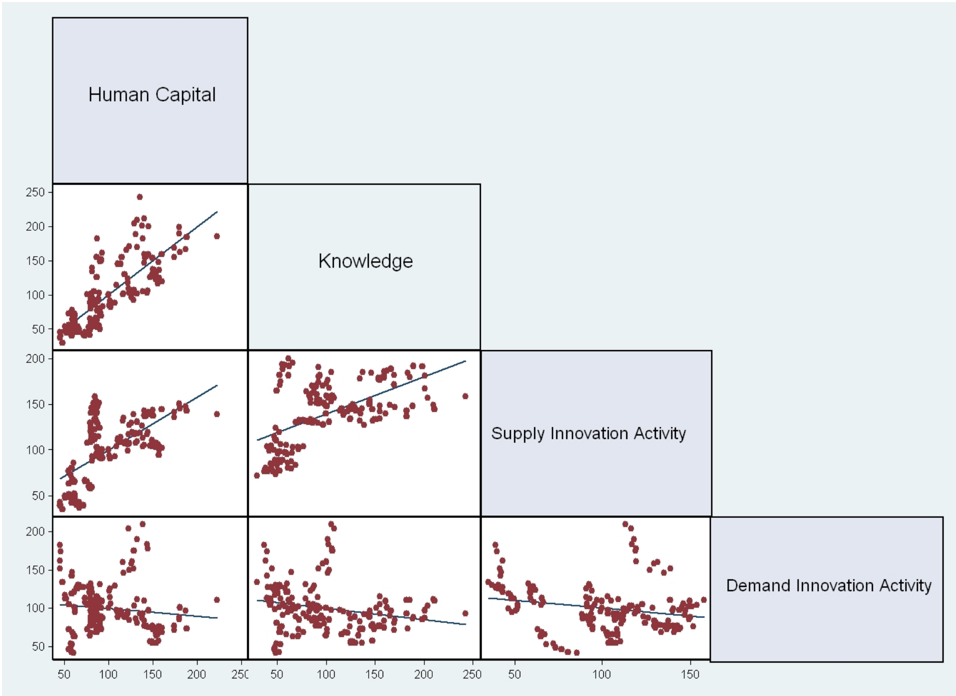

Figure 6: Correlations among the four dimensions

human capital capacity to have its effects on the production side. The most surprising part are the three last correlations. In the three of them, demand is either not related to the other indicators, or it is negatively related. In principle, we would expect that a population with higher education contains more sophisticated consumers. Also a positive relation would be expected between demand and knowledge, because knowledge in principle should be transformed into better things, which the consumer needs in oder to have a more pleasant life, but from the graphs this relationship is not apparent. The relation of the last square is a bit more complex, in the sense that there is no obvious theoretical reason why a society able to implement better the productive capacity will also be a society that is more dynamic from the demand side. And indeed we see no correlation.

So far the analysis has been at a very aggregated level, and one possible explanation for these results, is that in the graphs all the countries are together. It is probable that individual country effects are confounding the relationship between the indicators. Another possible explanation is that countries are not aware of this dimension, because the scientific community has always neglected the demand side. In trying to use the information that we have, we are going one step further analyzing the relation between the indicators and the growth of GDP per capita.

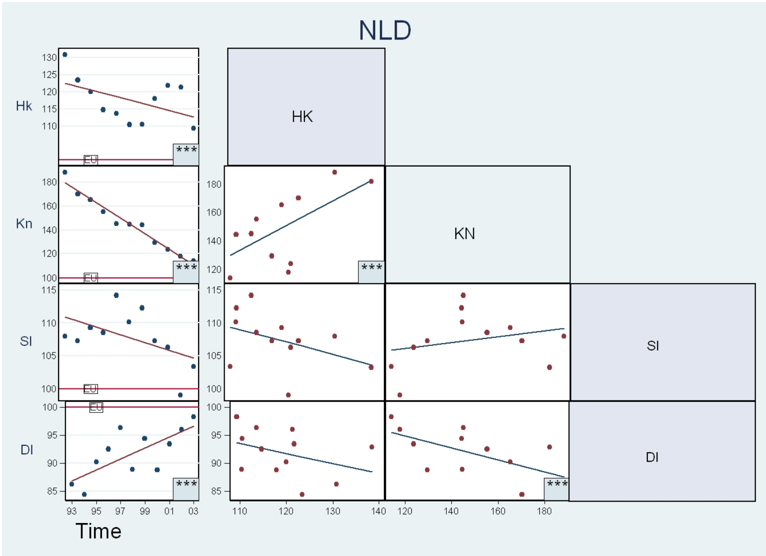

Figure 7: Netherlands National System of Innovations

4.1 The four dimensions at the country level

By the way the database has been built we have a panel data structure, which means we have evolution of the countries over time. In our sample we have European countries in a period that goes from 1993-2003. For every country we have a total of 10 years. The index in every year is the position of the country related to the EU-15 mean, therefore it does not have to be always increasing. The value of the indicator in each dimension should be interpreted in relation with the mean, so a country that has an index for one dimension which is constantly increasing over time it means that its position in relation with the EU-15 mean has been improving over the years.

The next graphical analysis will allow us to understand the evolution of each dimensions related to the European mean. As a first example we use the Dutch case, the data are presented in figure 7. In the left hand side of the figure, the evolution of the indicator over the time has been plotted. On the right side the relations among the four dimensions and how are they linked on their evolution.

The first horizontal block of four graphs present the evolution of the each of the dimensions: Human Capital (HK), Knowledge Creation (KN), Supply Innovation(SI) and Demand Innovation (DI). In each of these squares there is a red line, that marks the level at which the European Mean states. The line reminds constant because it has been used as a base to built the indicators. Each point is the value that the indicator takes for each year. The line in between the points is a linear regression[3], where we regress the value of the indicator on time, getting the linear trend. If the trend of indicator is statistically different from cero at the 1 % three stars apear in the right down part; two if it is significant at 5%, one start if it is significant at 10%, and no stars in any other case. For example, let us concentrate in the first square, where the evolution of Hk over the years has been presented. In the figure 7, human capital over the years is aproching the level of the European Union. This means that there is some convergency in this dimension for this country. And we see that this tendency is stadistically different from cero at the 1% level as it is shown by the three stars presented at right down corner. The same could be said for Knowledge Creation. But if we look at the supply innovation capacity of the country, even though we see that the trend is negative and moving towards the European mean from above, is is not significant. In this case we will asume that the level of the country remains constant over the period of study.

To the right side of the figure a matrix of plots is presented. In each of them the variables are being regressed to each other[4]. The linear regression line is also plotted and the stars explaining the significant level, with the same pattern as the one presented in the previous paragraph. In the example of the figure we can see that the movement in the dimension of human capital is related to the creation of knowledge. But we find no significant relation between this indicator and the changes in supply and demand innovations.

The Dutch case is a typical case of convergence, in which all the variables are moving or are close to the EU mean. The explanatory power of the indicator is reduced if the country remains always very close to the mean. Therefore in this case is difficult to reflect upon the links in the dimensions.

4.2 Weak links

Because it will be too long to analyze each graph for each country we choose three. These three are representative cases in which only one dimension seems to be weak. The rest of the graphs are presented in annex **??**. In this cases we suggests that policy should focus in this specific dimension. Let us have a look at three specific cases: Irland, Spain and Sweden.

The Irish system is presented in fig 8. Out of the four dimensions human capital is the weakest one. Knowledge, even though is behind the rest of the countries, is significantly approaching the average. The capacity to use knowledge to produce, i.e. the innovation capacity from the supply, is above the average of the EU, and present a divergent tendency. The demand

[3] It is a normal OLS regression in which we regress the values of the indicator over a linear trend. The significant level is related to the beta coefficient of such an excersice.

[4] similar to what we have done before but now we regress one indicator over the other. And the significant level represented by the number of stars is the significant level of the beta coefficient of such a regression

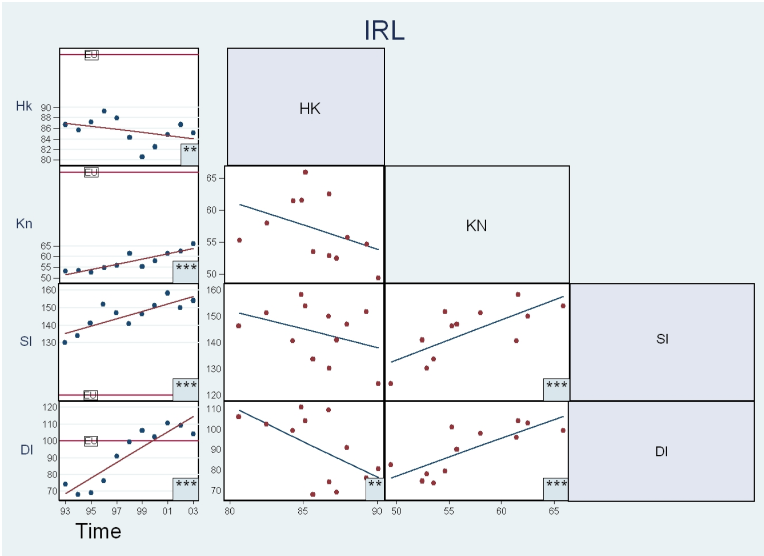

Figure 8: Ireland National System of Innovations

capacity is also positively growing. The weak link seems to be the formation of human capital. In the first square we can see that the tendency is to fall behind the rest of the of the countries. To be able to understand this case we have to think, that what is presented is the national effort to educate their population. One might wonder, who it is possible to generate knowledge is the people is not sufficiently educated. One possible answer are highly educated immigration. We can see that the national creation of knowledge, has a positive impact in the demand and supply of innovations. Clearly out of this brief analysis, the policy recommendation will be to strengh ways to generate human capital.

In the next example figure 9, the Spanish case, the weak side of the system comes from the incapacity of supply to use the knowledge. While we see a positive tendency for creation of knowledge, human capital formation, and demand innovation. The supply innovation variable is lagging behind the EU average and it does not present a tendency to converge. The interlinks presented in the matrix of correlations shows, that knowledge in its two forms codified and tacit, has a positive impact on the evolution of the demand, but it lacks the capacity to boost the innovation in the supply side. Clearly in this case the focus should be links between the existing knowledge and ways to improve the production process.

The last case presented is Sweden. In the human capital formation, albeit the tendency seems to be falling is not significant, which means that Sweden have found ways to maintain its superior education. In knowledge production presents a tendency to converge, however from above the average. And it its supply innovation capacity also present a stable case of superior

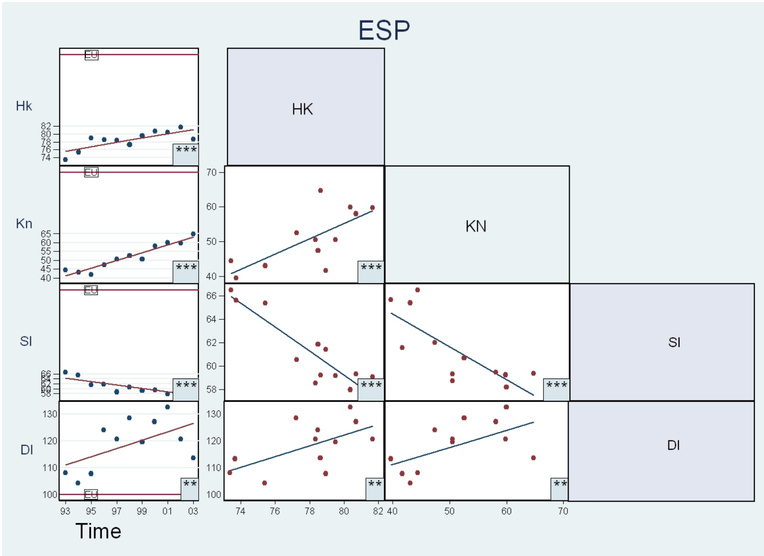

Figure 9: Spain National System of Innovations

capacity. But in the demand side, it is not even weak, but present a way to loose its momentum. The policy should concentrate in this case is ways to activate demand.

4.3 Country Groups

After a detailed analysis of the behavior of each country we are able to find some commonalities. First of all, presented in fig 11 we find that Austria, France, the Netherlands and Italy present a converging pattern. This countries either from above or below in most of the dimensions are moving toward the EU mean. The best case is the Netherlands. Austria present a perfect behaviour, with a capacity to push the frontier of knwoledge much faster than the rest of the countries. France and Italy lag behind in human capital formation.

The next group is Scandinavian countries, is presented by figure 12. The tree countries Sweden, Findland and Denmark present a very strong pattern in three dimensions: human capital, codified knowledge creation and in its capacity to use this knowledge to supply innovation. But also the three of them, present a very weak pattern in demand innovation. They seem to lack the capacity, to use the knowledge the have to activate the demand. One possible explanation could be that these countries are focused toward the international demand instead of the national one.

In figure 4.3 the cases of Irland, Portugal, Greece and Germany, are plotted together. The main commonality is to produce knowledge it is two main forms, tacit and codified. Very low trends for human capital, and

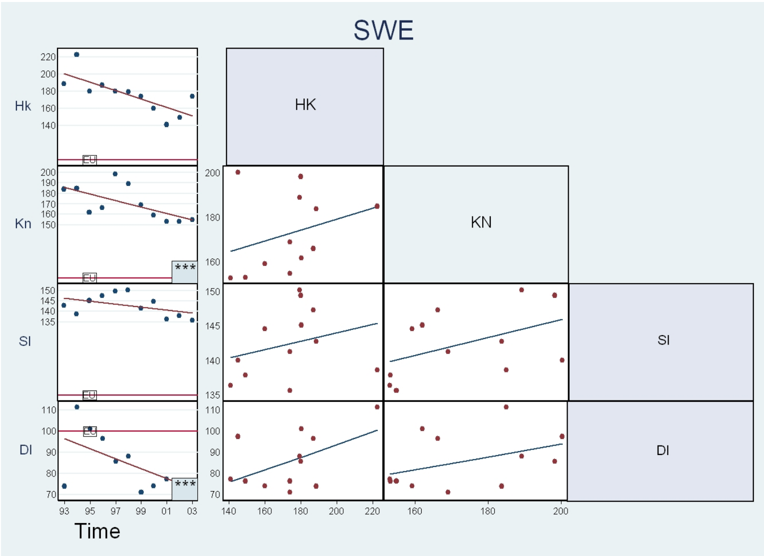

Figure 10: Sweden National System of Innovations

with the exception of Greece all of them seem to be lagging behind in this dimension. Low standard also for codified knowledge although all present converging patterns.

The last group is form by the United Kingdon, Spain and Belgium. The common characteristic among the three of them, is the strong growth in the demand to absorb innovations. It seems to be the key factor in the NSI. Spain and Belgium present very low levels of supply innovation therefor policy should be focused in this points.

5 Conclusions

The inclusion of the demand, as more active component of the system, brings us some interesting conclusions. First, Scandinavian countries, that normally stand above the European average in innovation activities; present a very weak demand side.

The analysis offers an interesting perspective of the NSI, based on the dynamics over ten years of four composite indicators. Bringing some light into the methodology to brings indicators, offers a distinctive approach toward the study of the dynamics and interaction in time and space of such indicators.

One conclusion of this chapter is that a healthy national system of innovation is the one that is able to generate synergies using links among the different parts of the society. Looking at the four dimensions we present an interesting exercise that might explain what is happening with the overall

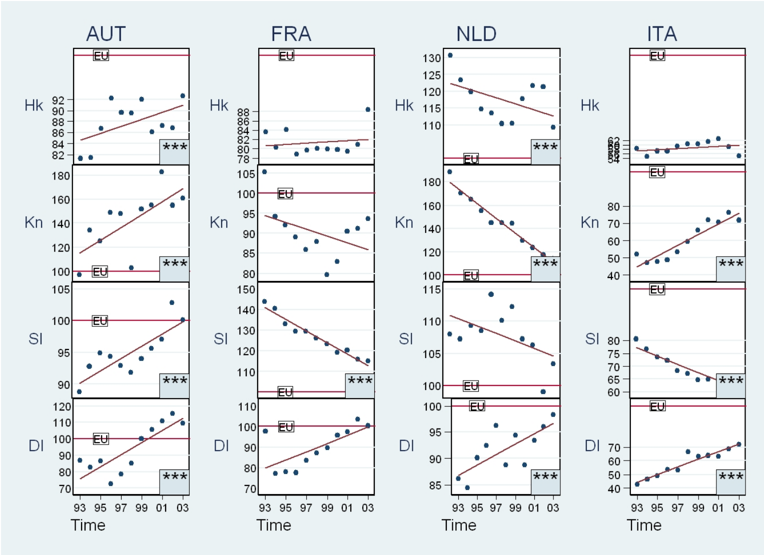

Figure 11: Countries presenting converging patterns

performance of the country in relation with its capacity to generate innovation.

With the analysis, we have also seen that the countries of the EU-15 present very different capacities to acquired competitive advantages. Specially the inclusion of demand dynamics make out of Scandinavian countries perfect goals of policies that activate this demand.

Our analysis is limited by the availability of data, and by the difficulties presented by any exercise using indicators. Further analysis might be useful to clarify the implication of the relations that we find.

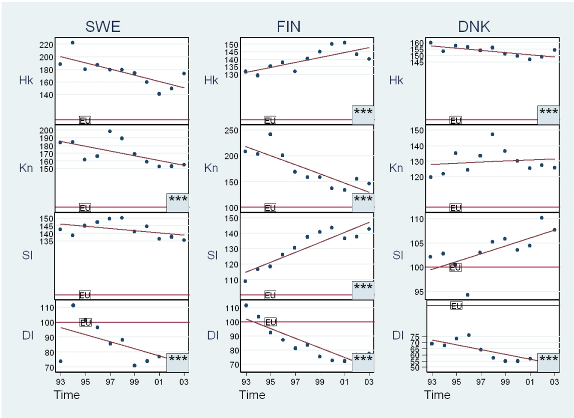

Figure 12: Scandinavian Countries

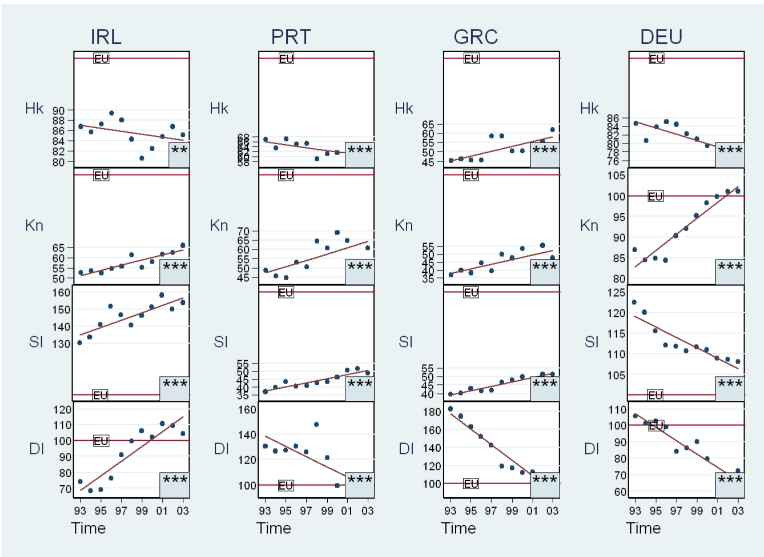

Figure 13: Countries with a weak production of knowledge

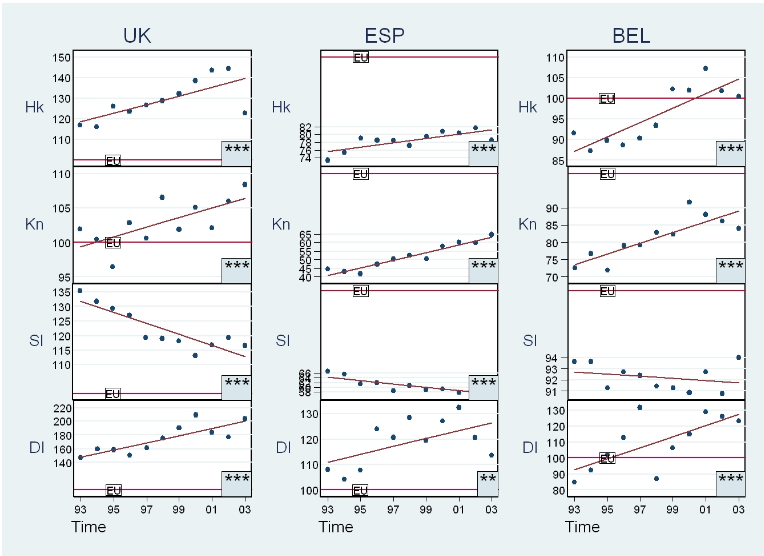

Figure 14: Countries presenting a strong demand

References

Alonso-Carrera, J., J. Caballe, and X. Raurich (2004). Consumption externalities, habit formation and equilibrium efficiency. *Scandinavian Journal of Economics 106*(2), 231–51. TY - JOUR Accession Number: 0751081 . Keywords: Accumulation; Capital; Consumption; Equilibrium; Externalities; Habit Formation; Welfare. Publication Type: Journal Article. Update Code: 200410.

Alvarez-Cuadrado, F., G. Monteiro, and S. J. Turnovsky (2004). Habit formation, catching up with the joneses, and economic growth. *Journal of Economic Growth 9*(1), 47–80. TY - JOUR Accession Number: 0736243 . Keywords: Economic Growth; Growth; Habit Formation. Publication Type: Journal Article. Update Code: 200407.

Benhabib, J. and A. Bisin (2000). Adverstising, mass consumption and capitalism. *http://www.econ.nyu.edu/user/benhabib/research.htm February.*

Bowen, H. P. and W. Moesen (2005). Benchmarking the competitiveness of nations: No- uniform weighting and non-economic dimensions. *(Mimeo).*

Carroll, C. D., J. Overland, and D. N. Weil (1997). Comparison utility in a growth model. *Journal of Economic Growth 2*(4), 339–67. TY - JOUR Accession Number: 0459670 . Keywords: Growth; Saving. Publication Type: Journal Article. Update Code: 199807.

Carroll, C. D., J. Overland, and D. N. Weil (2000). Saving and growth with habit formation. *American Economic Review 90*(3), 341–55. TY - JOUR Accession Number: 0531403 . Keywords: Consumer; Growth; Habit Formation; Saving. Publication Type: Journal Article. Update Code: 200009.

Carroll, C. D. and D. N. Weil (1994). Saving and growth: A reinterpretation. *Carnegie-Rochester Conference Series on Public Policy 40*(0), 133–92. TY - JOUR Accession Number: 0344202 . Keywords: Consumption; Growth; Households; Saving. Geographic Descriptors: Selected Countries; U.S.. Publication Type: Journal Article. Update Code: 199503.

Chang, P.-L. and H.-Y. Shih (2005). Comparing patterns of intersectoral innovation diffusion in taiwan and china: A network analysis. *Technovation 25*, 155–196.

Cherchye, L., W. Moesen, and T. Van Puyenbroeck (2004). Legitimately diverse, yet comparable: On synthesizing social inclusion performance in the eu. *Journal of Common Market Studies 42*(5), 919–55. TY - JOUR Accession Number: 0770601 . Geographic Descriptors: EU. Publication Type: Journal Article. Update Code: 200504.

Chiesa, V. and R. Manzini (1998). Towards a framework for dynamic technology strategy. *Technology Analysis and Strategic Management 10*(1), 111–29. TY - JOUR Accession Number: 0459940 . Keywords: Technology. Publication Type: Journal Article. Update Code: 199807.

Coombs, R., P. Narandren, and A. Richards (1996). A literature-based innovation output indicator. *Research Policy 25*, 403–413.

Dalum, B. (1992, 1992///). Export specialisation, structural competitiveness and national systems of innovation. TY - GEN Accession Number: 0367393 . Editor: Lundvall, Bengt-Ake, ed.. Keywords: Exports. Geographic Descriptors: OECD. Publication Type: Collective Volume Article. Update Code: 199512.

Dang Nguyen, G. and M. Jolles (2005). Does the european union create the foundations of an information society for all? *Bruges European Economic Policy Briefings 11.*

Dosi, G., K. Pavitt, and L. Soete (1990). *The Economics of Technical Change and Interantional Trade*. Harvest Wheatsheaf.

Duesenberry, J. S. (1949). *Income, Saving and the Theory of the Consumer Behaviour*. Cambridge Mass.: Harrod University Press.

Edquist, C. (1995). Government technology procurement as an instrumetn of technology policy. In M. J. M. Teubal, D. Foray and E. Zucovitch (Eds.), *Technological Infrastructure Policy (TIP)*. Dordrecht-Boston London: Kluger.

Edquist, C. (1997). Systems of innovation approaches–their emergence and characteristics. In *Systems of Innovation*, pp. 1–35. London (UK): Series Editor: John de la Mothe.

Fagerberg, J. (1992, 1992///). The home market hypothesis re-examined: The impact of domestic user-producer interaction on export specialisation. TY - GEN Accession Number: 0367394 . Editor: Lundvall, Bengt-Ake, ed.. Keywords: Exports. Geographic Descriptors: OECD. Publication Type: Collective Volume Article. Update Code: 199512.

Freeman, C. (1982). Technological infraestructure and international competitiveness. *Reprint for The First Globelics Conference. Draft paper submitted to the OECD.*

Freeman, C. (1995). The 'national system of innovation' in historical perspective. *Cambridge Journal of Economics 19*(1), 5–24. TY - JOUR Accession Number: 0353835 . Keywords: Innovation. Geographic Descriptors: Selected Countries. Publication Type: Journal Article. Update Code: 199508.

Freeman, C. (2002). Continental, national and sub-national innovation systems–complementarity and economic growth. *Research Policy 31*(2), 191–211. TY - JOUR Accession Number: 0604512 . Keywords: Economic Growth; Growth; Innovation. Geographic Descriptors: Global. Publication Type: Journal Article. Update Code: 200205.

Fuhrer, J. C. (2000). Habit formation in consumption and its implications for monetary-policy models. *American Economic Review 90*(3), 367–90. TY - JOUR Accession Number: 0531405 . Keywords: Consumer; Consumption; Habit Formation; Monetary Policy; Monetary; Policy. Geographic Descriptors: U.S.. Publication Type: Journal Article. Update Code: 200009.

Furman, J. L., M. E. Porter, and S. Stern (2002). The determinants of national innovative capacity. *Research Policy 31*(6), 899–933. TY - JOUR Accession Number: 0614999 . Geographic Descriptors: Selected Countries. Publication Type: Journal Article. Update Code: 200208.

Godhino, M. M., S. Mendoa, and T. Santos-Pereira (2005). Towards a taxonomy of innovation systems. *http://pascal.iseg.utl.pt/d̃epteco/iseg_ecosemin0405_mmgodinhopaper.pdf WP 13/2005/DE/CISEP*(ISEG-UT Lisabon University).

Gregersen, B. (1992, 1992///). The public sector as a pacer in national systems of innovation. TY - GEN Accession Number: 0367390 . Editor: Lundvall, Bengt-Ake, ed.. Keywords: Innovation. Publication Type: Collective Volume Article. Update Code: 199512.

Hufbauer, G. (1970). The impact of national characteristics and technology on the commodity composition of trade in manufactured goods. In R. Vernon (Ed.), *The Technology Factor in International Trade*. New York: Harvard University Press.

Kaiser, R. and H. Prange (2004). The reconfiguration of national innovation systems–the example of german biotechnology. *Research Policy 33*(3), 395–408. TY - JOUR Accession Number: 0736905 . Keywords: Bio Technology; Biotechnology; Innovation. Geographic Descriptors: Germany. Publication Type: Journal Article. Update Code: 200407.

Liu, X. and S. White (2001). Comparing innovation systems: A framework and application to china's transitional context. *Research Policy 30*(7), 1091–1114. TY - JOUR Accession Number: 0590474 . Geographic Descriptors: China. Publication Type: Journal Article. Update Code: 200112.

Lundvall, B.-A. (1992, 1992///). User-producer relationships, national systems of innovation and internationalisation. TY - GEN Accession Number: 0367386 . Editor: Lundvall, Bengt-Ake, ed.. Keywords: Innovation. Publication Type: Collective Volume Article. Update Code: 199512.

Lundvall, B.-A. (2005). National innovation systems- analytical concept and development tool. *Paper to be presented at the DRUID tenth Anniversary Summer Conferences.*.

Malerba, Franco, e. (2004). *Sectoral systems of innovation: Concepts, issues and analyses of six major sectors in Europe.* Cambridge; New York and Melbourne: Cambridge University Press. TY - BOOK Accession Number: 0767373 . Publication Type: Book. Update Code: 200504.

Metcalfe, J. S. (1995). Technology systems and technology policy in an evolutionary framework. *Cambridge Journal of Economics 19*(1), 25–46. TY - JOUR Accession Number: 0353836 . Keywords: Technology. Publication Type: Journal Article. Update Code: 199508.

Montobbio, F. (2000). Instituzioni e attivita innovativa: i sistemi inovativi. In F. Malerba (Ed.), *Economia dell' Innovazione.*

Montobbio, F. (2001). *The Dynamics of Industries: Essays on Structural Change, Technological Spillovers and Patterns of International Specialisation.* Ph. D. thesis, University of Manchester (UK).

Nardo, M., M. Saisana, A. Salteli, S. Tarantola, A. Hoffman, and E. Giovannini (2005). Handbook on constructing composite indicators: Methodology and user guide. *OCDE Statistic Working Paper 3.*

Nasierowski, W. and F. Arcelus (1999). Interrelationsships among the elements of national innovation systems: A statistical evaluation. *European Journal of Operational Reserach 119*, 235–253.

Perez, C. (1985). Microelectornics, long waves and world structural change: New perspectives for developing countries. *World Development 13*(3), 441–463.

Perez, C. (1988). New technologies and development. In C. Freeman and B.-A. Lundvall (Eds.), *Small Contires Facing the Technological Revolution.* London: Biddle of Guildford.

Pollak, R. A. (1970). Habit formation and dynamic demand functions. *The Journal of Political Economy 78*(4, Part 1), 745–763. FLA Part 1 00223808 The University of Chicago Press EN Copyright 1970 The University of Chicago Press.

Porter, M. E. (1990). *The competitive advantage of nations.* The Macmillan Press LTD.

Porter, M. E. and S. Stern (2001). National innovative capacity. *The Global Competitiveness Report 2001-2002 http://www.isc.hbs.edu/Innov_9211.pdf.*

Posner, M. (1961). International trade and technical change. *Oxford Economic Papers October.*

Rosenberg, N. (1969). The direction of technological change: Inducement mechanisms and focusing devices. *Economic Development and Cultural Change 18*(1), 1–24. TY - JOUR Accession Number: 0050958 . Publication Type: Journal Article. Update Code: 199006.

Ryder, Harl E., J. and G. M. Heal (1973). Optimal growth with intertemporally dependent preferences. *The Review of Economic Studies 40*(1), 1–31. FLA 00346527 Economic Study Society Copyright 1973 The Review of Economic Studies Ltd.

Saisana, M., A. Salteli, and S. Tarantola (2005). uncertainty and sentitivity analysis techniques as tools for the quality assessment of composite indicators. *Journal of Royal Statistical Society 168*(part 2), 307–323.

Schmookler, J. (1971). Economics sources of inventive capacity. *in N. Rosemberg(ed) The Economics of Techonological Change*.

Scitosvky, T. (1977). *The joyless economy : an inquiry into human satisfaction and consumer dissatisfactionn.* Oxford University Press.

von Hippel, E. (1986). Lead users: A source of novel product concepts. *Management Science 32*(7), 791–805.

von Hippel, E. (1988). *The sources of innovation.* New York; Oxford; Toronto and Melbourne: Oxford University Press. TY - BOOK Accession Number: 0042628 . Publication Type: Book. Update Code: 199006.

The UNU-MERIT WORKING Paper Series

2007-01 *Developing science, technology and innovation indicators: what we can learn from the past* by Christopher Freeman & Luc Soete

2007-02 *The impact of innovation activities on productivity and firm growth: evidence from Brazil* by Micheline Goedhuys

2007-03 *Estimations of US debt dynamics: Growth cum debt and the savings glut in Kouri's model* by Thomas Ziesemer

2007-04 *States and Firms on the Periphery: The Challenges of a Globalising World* by Gabriel R.G. Benito & Rajneesh Narula

2007-05 *How Do Consumers Make Choices? A Summary of Evidence from Marketing and Psychology* by Zakaria Babutsidze

2007-06 *Inter-firm Technology Transfer: Partnership-embedded Licensing or Standard Licensing Agreements?* by John Hagedoorn, Stefanie Lorenz-Orlean & Hans Kranenburg

2007-07 *The Behavior of the Maximum Likelihood Estimator of Dynamic Panel Data Sample Selection Models* by Wladimir Raymond, Pierre Mohnen, Franz Palm & Sybrand Schim van der Loeff

2007-08 *Location and R&D alliances in the European ICT industry* by Rajneesh Narula & Grazia D. Santangelo

2007-09 *How do social capital and government support affect innovation and growth? Evidence from the EU regional support programmes* by Semih Akcomak & Bas ter Weel

2007-10 *The Micro-Dynamics of Catch Up in Indonesian Paper Manufacturing: An International Comparison of Plant-Level Performance* by Michiel van Dijk & Adam Szirmai

2007-11 *Financial Constraint and R&D Investment: Evidence from CIS* by Amaresh K Tiwari, Pierre Mohnen, Franz C. Palm & Sybrand Schim van der Loeff

2007-12 *The Spatial Hierarchy of Technological Change and Economic Development in Europe* by Bart Verspagen

2007-13 *The origins and implications of using innovation systems perspectives in the design and implementation of agricultural research projects: Some personal observations* by Andy Hall

2007-14 *Technology supply chain or innovation capacity?: Contrasting experiences of promoting mall scale irrigation technology in South Asia* by Andy Hall, Norman Clark and Guru Naik

2007-15 *Are firms that received R&D subsidies more innovative?* by Charles Bérubé & Pierre Mohnen

2007-16 *Foreign direct investment and firm level productivity. A panel data analysis* by Geoffrey Gachino

2007-17 *Technological spillovers from multinational presence towards a conceptual framework* by Geoffrey Gachino

2007-18 *Technological capability building through networking strategies within high-tech industries* by Wim Vanhaverbeke, Bonnie Beerkens and Geert Duysters

2007-19 *External technology sourcing: the effect of uncertainty on governance mode choice* by Vareska van de Vrande, Wim Vanhaverbeke & Geert Duysters

2007-20 *Exploration and Exploitation in Technology-based Alliance Networks* by Wim Vanhaverbeke, Victor Gilsing, Bonnie Beerkens, Geert Duysters

2007-21 *ICT Externalities: Evidence from cross country data* by Huub Meijers

2007-22 *Knowledge Flows, Patent Citations and the Impact of Science on Technology* by Önder Nomaler & Bart Verspagen

2007-23 *R&D offshoring and technology learning in emerging economies: Firm-level evidence from the ICT industry* by Zhe Qu, Can Huang, Mingqian Zhang & Yanyun Zhao

2007-24 *The Environmental Porter Hypothesis: Theory, Evidence and a Model of Timing of Adoption* by Ben Kriechel & Thomas Ziesemer

2007-25 *Measuring the Effectiveness of R&D tax credits in the Netherlands* by Boris Lokshin & Pierre Mohnen

2007-26 *The productivity effects of internal and external R&D: Evidence from a dynamic panel data model* by Boris Lokshin, René Belderbos & Martin Carree

2007-27 *National System of Innovations and the role of demand. A cross country comparison* by M. Abraham Garcia-Torres.