

Determinants of innovative capacity: the case of European peripheral regions

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Abstract

The paper aims to study the drivers of innovative capacity of European peripheral regions. To achieve this objective, we apply the Furman et al. (2002) model at regional level which allows us to test if this model is applicable at regional level. Regarding to this point, it constitutes the second objective of the paper. We empirically study the drivers of innovative capacity in European peripheral regions by providing econometric analysis of panel data methodology based on data from the Eurostat for the period 1996-2007. The empirical results highlight the importance the importance of some factors related to the quality of common innovation infrastructure and the cluster-specific innovation environment on the regional innovative capacity. However, the quality of linkages doesn't seem to have a significant effect on regional innovative capacity.

Key words

Innovative capacity; Europe; Peripheral regions

1. Introduction

In the modern economy, innovation is considered a key factor in the sense that in practically all parts of the economy can be identified processes of learning and producing knowledge, which result in new products, new techniques, new forms of organization and new markets. Thus, it can be argued that the long term competitiveness of firms, and of national economies, reflect their innovative capability. The importance of innovation for economic growth has been long studied in the literature and economists have adopted different frameworks for the analysis of this relationship (Fagerberg et al., 2006). These approaches started with classical economists as Adam Smith, Malthus or Schumpeter proposing the importance of innovation for economic growth. The next step was the development of the “neoclassical growth models” which treated technology change as an exogenous phenomenon (Abramovitz, 1956; Solow, 1956; 1957; Denison, 1962; 1967) and that empirically studied the determinants of economic growth, the so-called “growth-accounting”. Next, efforts to endogenize “technology” were made. Along these lines Arrow (1962) proposed a model of economic growth in which technical change is endogenized in the name of “learning” by doing that could be understood as a pioneering study of “the new growth theory”. The new growth theory was started by the seminal work of Romer (1986) where the neoclassical assumptions were abandoned. Within this approach several models (Romer, 1987; Lucas, 1988; Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992) have studied the long-term growth for a model of technological progress. Finally, “the evolutionary tradition” studied the role of technological change in economic growth too. From this point of view growth is a process that takes place in historical time and interacts with, and it is influenced by, many factors that are more or less outside the economic domain (culture, institutions, science) (Verspagen, 2000). Therefore, evolutionary economics view technology as a socio-technical system (Nelson and Winter, 1982). Fagerberg (1987; 1988; 1991) developed a series of empirical studies that confirmed the importance of both technology and social factors in economic growth.

Because of the abovementioned importance of innovation on economic growth, which has received both theoretical and empirical support, literature has focused on identification of factors that affect innovative capacity (Varsakelis, 2006). Along these lines, and motivated by differences in innovation intensity across advanced economies too, Furman et al. (2002) developed a framework based on the concept of national

innovative capacity which can be understood as the ability of a country to produce and commercialize a flow of innovative technology over the long term. This approach investigates the overall sources of innovation systems at a country level drawing on three main sets of ideas (Krammer, 2009): the Knowledge Production Function (KNF) from endogenous growth theory (Romer, 1986); Porter's (1990) interaction between the private sector and the national industrial clusters; and the National Innovation Systems literature (Nelson, 1993; Dosi, 1988; Edquist, 1997). From these sets of ideas the authors identify the following dimensions of determinants of the innovative capacity: the quality of the common innovation infrastructure, the cluster-specific environment and the quality of linkages.

The importance of innovation at regional level has emerged in the advanced industrialized nations since the mid-1970s (Park and Lee, 2004). Its importance is due to the fact that industries tend to concentrate in specific spaces, as well as on the existence of policies applied at regional level (Porter, 1990). Moreover, in a regional environment it is easier to obtain enough proximity to support the necessary communication for the development of technological innovations (Gregersen and Johnson, 1997). Therefore, a region can represent a good platform for technological innovation, which is often very complex and requires the cooperation of the different actors at a regional level (Meyer-Kramer, 2001). Finally, as a consequence of the processes of regionalization and globalization, the regional environment is as relevant as the national one in determining the ability of enterprises to compete in all economic levels (Chatterton and Goddard, 2000). From the European perspective, the regions play the main role in creating economic development (Park and Lee, 2005).

Due the importance of the regional level of analysis in Europe, in this paper we study the determinants of innovation capacity for European regions. In more precise terms, we focus our analysis on the study of the European peripheral regions. A region is peripheral not only in a geographic sense. In a broad sense peripheral regions those regions that start from a weakness respecting to other regions en terms of less equipment, less industrial infrastructure, weak firm networks and weak innovation culture (Gonzalez Ramos and González de la Fe, 2009). These regions have been defined by the European Commission through the development of an index of accessibility. This index measures for each region the time needed to reach other regions weighted by their economic importance. It should be emphasised that this index involves a good deal of estimation and that it represents the position at the present time

rather than what it might be in the future, given the current development of infrastructure in peripheral regions (partly financed by the Structural Funds) and, perhaps more importantly, given the implications for the concept of accessibility of the development of the information society. Regions can be divided into three groups in the terms of the index (figure 1):

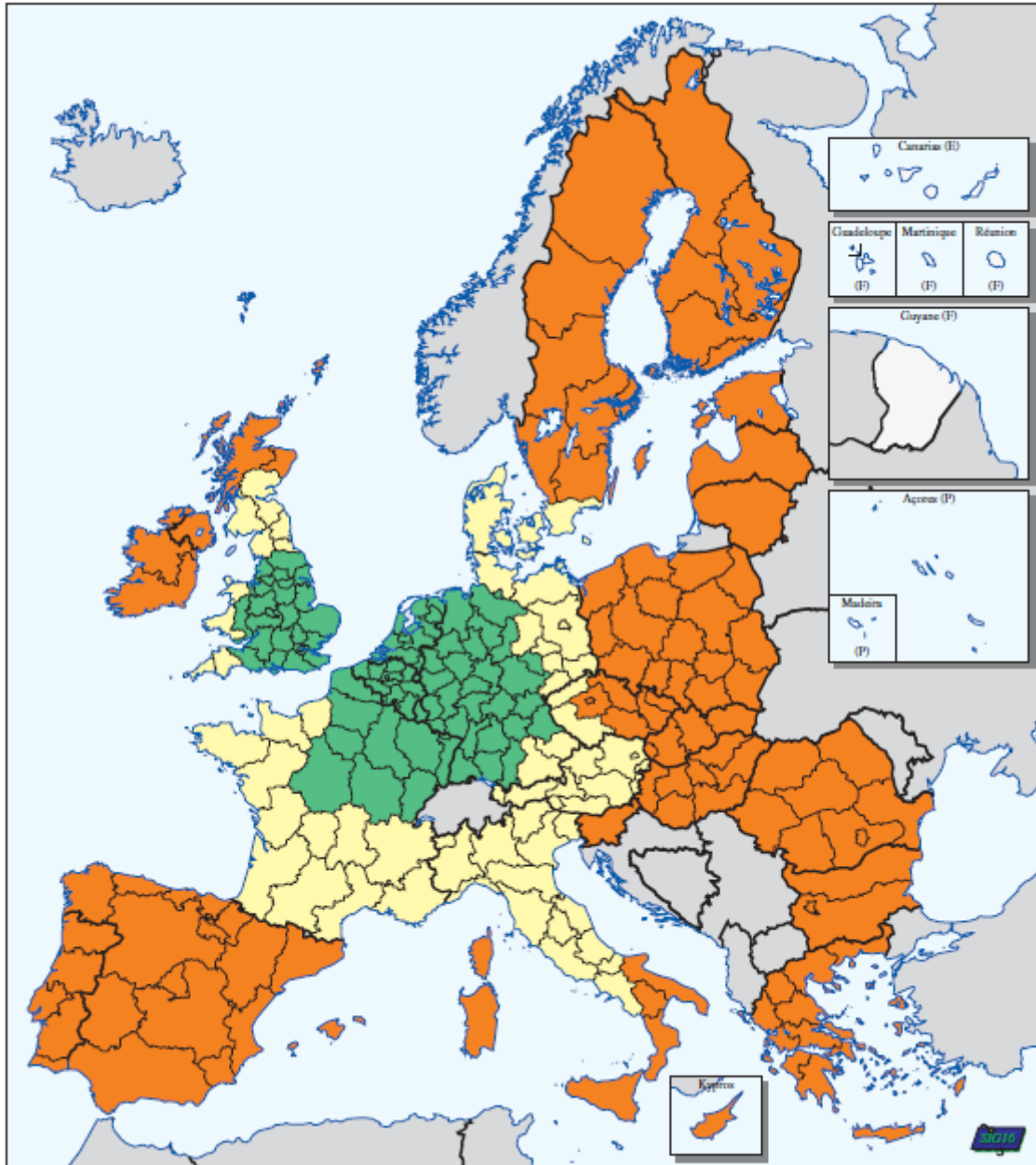
- Central regions, for which the accessibility index is over 50% above the average for the EU plus the 12 accession countries, situated in the triangle North Yorkshire (UK), Franche-Comté (France), Hamburg (Germany);
- Peripheral regions, for which the index is under 40% of the average, situated in the north of Europe, in Sweden and Finland; in the north-west, in northern Scotland and Ireland; in the south, in Portugal, Spain, the Mediterranean islands, the southern tip of Italy and Greece, and in the east in the candidate countries.
- Regions in between with an index of between 40% and 150% of the average.

As far as the peripheral regions is concerned, its study is of interest due the majority of the previous literature has been mainly focused on the most successful regions in innovation terms as the case of Japan, Silicon Valley, Manchester or Lyon (González Ramos and González de la Fe, 2009).

Therefore, the aim of the paper is to study the determinants of innovative capacity in peripheral European regions. To achieve this objective we use the abovementioned Furman et al. (2002) model. Although the framework was created for application at the national level, it can also be employed to evaluate innovative capacity at the regional or local level (Gans and Stern, 2003). Therefore, we empirically study the drivers of innovative capacity applying the Furman et al. (2002) model at regional level by providing econometric analysis based on data from the Eurostat at regional level (NUTS 2).

To achieve this objective the paper is organized as follows. In section two we present the literature review about the study of the determinants of innovative capacity at geographical level. Section three presents the data sources, the methodology and the construction of the variables for the empirical analysis. The empirical findings are presented in section four and the final section contains the conclusions, implications and limitations of the research.

Figure 1: European peripheral regions



A.4 Central and peripheral regions

- Central regions
- Peripheral regions
- Other regions

According to the peripherality index to GDP in Euro by territory (NUTS2)

Source: IRPUD - DGREGIO

0 100 500 km

© MEGRIN for the administrative boundaries

SOURCE: Eurostat

2. Literature review

We base our analysis on the conceptual framework for understanding innovative capacity outlined in Furman et al. (2002). This framework is built on three main approaches of sources of innovation:

- Models of ideas-driven endogenous economic growth theory (Romer, 1986; Jones, 1998): from this point of view economic growth depends on the production of the ideas-generating sector of the economy. According to this, the rate of new ideas production is a function of the stock of knowledge (previous generated ideas) and the extent of efforts (human and financial capital) devoted to the ideas-generating portion of the economy (Furman and Hayes, 2004).
- The cluster-based theory of national industrial competitive advantage (Porter, 1990): this perspective regards the manner in which microeconomic processes interact with macroenvironment and national institutions to affect the overall level of innovative activity in an economy. Porter identifies four key drivers in the national industry clusters: the quality and specialization of innovation outputs, the context for firm strategy and rivalry and the demand conditions.
- The National Innovation Systems approach (Nelson, 1993; Dosi, 1988; Edquist, 1997): this approach emphasizes the array of national policies, institutions and relationships that drive the nature and extent of country innovative output (Furman and Hayes, 2004). This literature highlights the nature of the university system, the extent of intellectual policy protection, the historical evolution of the organization of industrial R&D and the division of labour between private industry, universities and government in R&D performance and funding (Furman et al., 2002).

From these approaches, Furman et al. (2002) developed a model for the study of the determinants of national innovative capacity. They divided these determinants into three categories: the common innovation infrastructure, the cluster-specific innovation environment and the quality of linkages between them (figure 2).

1. The common innovation infrastructure: these set of determinants are composed by the investments that support innovative activity affecting all innovation-oriented sectors in an economy. Models of ideas-based growth highlight two main determinants of the national innovative capacity related to its common innovation infrastructure: an economy's aggregate level of technological sophistication that refers to its historical stock of knowledge (A) and the size of the available pool of

scientists and engineers who may be dedicated to the production of new technologies (H_A). Furthermore, Furman et al. (2002) included other factors that impact innovative activity related to national investments and policy choices (X^{INF}) such as the investments in higher education, intellectual property protection and openness to international competition.

2. The cluster-specific innovation environment: from this point of view Furman et al. (2002) considered that despite the common innovation infrastructure sets the general context for innovation in an economy, are ultimately firms, influenced by their microeconomic environment, that develop and commercialize innovations. Furman et al. (2002) and Furman and Hayes (2004), drawing on Porter's "diamond" framework, proposed four main elements of this microeconomic environment: the presence of high quality and specialized inputs; a context that encourages investment and intense local rivalry; demand conditions; and the presence of a cluster of related and supporting industries.
3. The quality of linkages: the relation between the abovementioned elements (common innovation infrastructure and cluster-specific innovation environment) will determine the extent to which the potential for innovation, supporting by innovation infrastructures, will become into innovative outputs in innovation clusters (Furman and Hayes, 2004). In more precise terms, Furman et al. (2002) proposed that in the absence of the strong linking mechanisms, innovation outputs may spill over to other countries before local industries can exploit them. In this way, the linkages between innovation infrastructure and the cluster-specific innovation environment became one of the main drivers of national (or regional) innovative capacity.

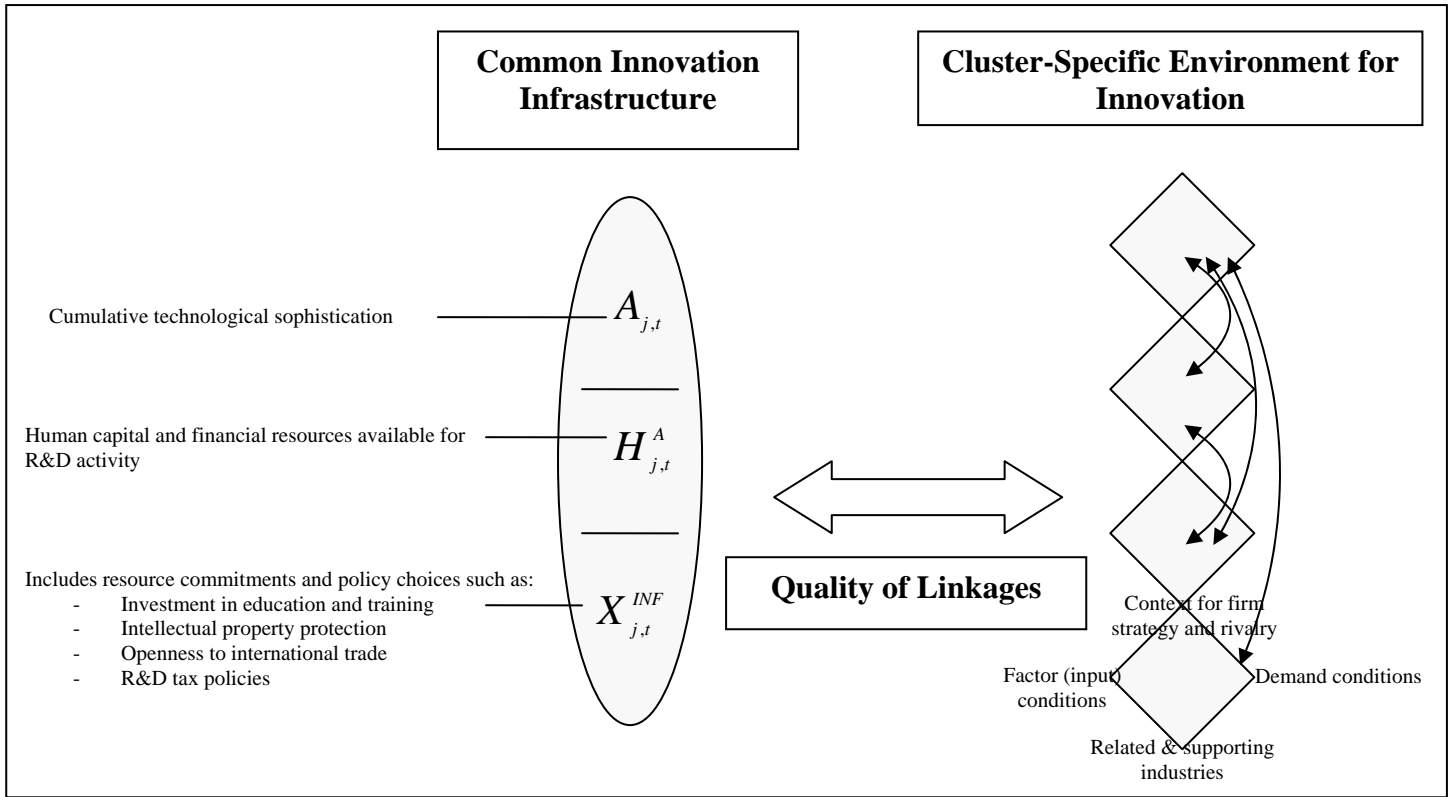
Based on the national innovative capacity framework presented before, Furman et al. (2002) used a production function for new-to-the-world technologies more general than Romer (1990) formulation. This function is specified as:

$$A_{j,t} = \delta_{j,t} (X_{j,t}^{INF}, Y_{j,t}^{CLUS}, Z_{j,t}^{LINK}) H_{j,t}^{A\lambda} A_{j,t}^{\phi}$$

In order to test their model, Furman et al. (2002) identified a set of indicators related to the national common innovation infrastructure, the cluster-specific innovation environment and the quality of linkages between them. Based on the model, other authors (Gans and Stern, 2003; Riddel and Schwer, 2003; Furman and Hayes, 2004; Hu

and Mathews, 2005; Hu and Mathews, 2008; Krammer, 2009) have empirically tested the influence of this set of indicators whose main results we show in following lines.

Figure 2: National innovative capacity framework



SOURCE: *Furman et al. (2002)*

- Starting with the common innovation infrastructure, the indicators identified are the stock of knowledge ($A_{j,t}^{\phi}$), the level of capital and human resources ($H_{j,t}^{A\lambda}$) and other factors that impact innovative activity related to national investments and policy choices ($X_{j,t}^{INF}$).

Regarding to the stock of knowledge ($A_{j,t}^{\phi}$) they take as indicators the GDP per capita or the stock of international patents. Starting with the GDP per capita Furman et al. (2002), Stern and Gans (2003) and Furman and Hayes (2004) found a positive and significant effect on national innovative capacity while Hu and Mathews (2005) and Hu and Mathews (2008) didn't confirm statistically this positive relation. Following with patent stock, the empirical evidence is less homogeneous. A positive and significant relation is empirically confirmed by Furman et al. (2002), Riddel and Schwer (2003), Hu and Mathews (2005) and Krammer (2009). However, the empirical evidence from Hu and Mathews

(2008) showed a negative and significant effect of the level of patent stock on national innovative capacity.

Following with the level of capital and human resources ($H_{j,t}^{A\lambda}$), the indicators selected are the population, the employed S&T personnel and the level of total R&D expenditures. As far as the population is concerned the empirical evidence is not conclusive. Some authors find that the level of population has a positive effect on national innovative capacity (Hu and Mathews, 2008; Krammer, 2009) whereas others (Furman et al., 2002; Hu and Mathews, 2005) find the opposite to be the case, i.e. that a negative relation exists.

With respect to the available empirical evidence about the effect of the employed S&T personnel, it confirms a positive effect on national innovative capacity (Furman et al., 2002; Gans and Stern, 2003; Riddel and Schwer, 2003; Furman and Hayes, 2004; Hu and Mathews, 2005; Krammer, 2009) with the exception of Hu and Mathews (2008) whose results propose a negative effect.

Finally, several empirical papers have studied the relation between the level of total R&D expenditures and the national innovative capacity and the majority of them confirm a positive and significant relation (Furman et al., 2002; Gans and Stern, 2003; Furman and Hayes, 2004; Hu and Mathews, 2005; Krammer, 2009). Hu and Mathews (2008) for their part, found a positive but not significant relation.

As far as the national policies and other commitments ($X_{j,t}^{INF}$) is concerned they take the level of openness to international trade and investment, the strength of IP protection, the share of GDP spent on higher education and the relative stringency of antitrust policies.

Firstly, a positive effect of international openness on national innovative capacity is empirically found in Furman et al. (2002)¹, Furman and Hayes (2004), Hu and Mathew (2005) and Hu and Mathew (2008).

Secondly, the empirical evidence related to the effect of the strength of IP protection on national innovative capacity is not conclusive. On the one hand, a

¹ If they use the GDP per capita as indicator of $A_{j,t}^{\phi}$ the effect of the openness to international trade and investment on national innovative capacity is positive and significant. However, if they use the previous patent stock as indicator of $A_{j,t}^{\phi}$ the effect is negative and not significant.

positive and significant effect is found in Furman et al. (2002), Gans and Stern (2003) and Furman and Hayes (2004) and a positive but not significant in Hu and Mathews (2005)². On the other hand, Hu and Mathews (2008) provide opposite empirical evidence, i.e. that the strength of IP protection has a negative and significant effect on national innovative capacity.

Thirdly, respecting to the share of GDP spent on higher education, the available empirical evidence suggests a positive effect on national innovative capacity. A positive and significant effect is empirically found in Furman et al. (2002), Gans and Stern (2003) and Furman and Hayes (2004) and a positive but not significant one in Hu and Mathews (2005)³ and Krammer (2009).

Fourthly, an indicator of the relative stringency of antitrust policies is identified into this group. The majority of the empirical evidence found a positive effect of this variable on national innovative capacity. This effect was statistically significant in Furman et al. (2002)⁴ and Hu and Mathews (2008) and not significant in Furman and Hayes (2004) and Hu and Mathews (2005).

- As far as the cluster-specific innovation environment is concerned ($Y_{j,t}^{CLUS}$), Furman et al. (2002) selected as indicators the intensity of privately financed R&D activity in an economy and the degree of technological focus by a country. On the one hand, a positive and significant effect of the private R&D expenditures on national innovative capacity is empirically supported by Furman et al. (2002), Gans and Stern (2003), Riddel and Schwer (2003), Furman and

² If they use the previous patent stock as indicator of $A_{j,t}^{\phi}$ the effect of the strength of IP protection on national innovative capacity is positive and not significant. However, if they use the GDP per capita as indicator of $A_{j,t}^{\phi}$ the effect is negative and not significant.

³ If they use the GDP per capita as indicator of $A_{j,t}^{\phi}$ the effect of the share of GDP spent on higher education on national innovative capacity is positive and not significant. However, if they use the previous patent stock as indicator of $A_{j,t}^{\phi}$ the effect is negative and significant.

⁴ If they use the previous patent stock as indicator of $A_{j,t}^{\phi}$ the effect of the relative stringency of antitrust policies on national innovative capacity is positive and significant. However, if they use the GDP per capita as indicator of $A_{j,t}^{\phi}$ the effect is negative and not significant.

Hayes (2004), Hu and Mathews (2005), Hu and Mathews (2008)⁵ and Krammer (2009).

On the other hand, the technological specialization is empirically found to have influence on national innovative capacity in Furman et al. (2002), Gand and Stern (2003), Hu and Mathews (2005) and Hu and Mathews (2008).

- And finally, Furman et al. (2002) used the share of total R&D accounted by universities and the availability of venture-backed financing as indicators of the quality of linkages ($Z_{j,t}^{LINK}$).

First, a positive and significant effect of the total R&D accounted by universities on national innovative capacity is empirically proved in Furman et al. (2002), Gans and Stern (2003), Furman and Hayes (2004), Hu and Mathews (2008) and Krammer (2009), and positive but not significant in Hu and Mathews (2005). However, the empirical results of Riddel and Schwer (2003) showed a negative but not significant effect.

Finally, the majority of the empirical evidence about the availability of venture-backed financing support the argument that it has a negative effect on national innovative capacity (Furman and Hayes, 2004; Hu and Mathews, 2005; Hu and Mathews, 2008) with the exception of the results provided by Furman et al. (2002), that suggest a negative effect but without statistical significance.

Therefore, the main conclusion from this literature review is that the importance of the majority of the factors of the three dimensions identified in the model of Furman et al. (2002) is confirmed. Thus, due it is a good model in order to study the determinants of innovation capacity at national level we are going to apply it at regional level by taking the same variables at this level but when the data availability makes it possible.

3. Data sources, methodology and variables

Sample and data

The sample used in this study is the 115 European peripheral regions corresponding to the level II NUTS according to the European nomenclature (table 1). However, due to the available data, the final sample used in our study is composed by a total of 99

⁵ If they use the previous patent stock as indicator of $A_{j,t}^{\phi}$ the effect of the private R&D expenditures on national innovative capacity is positive and significant. However, if they use the GDP per capita as indicator of $A_{j,t}^{\phi}$ the effect is negative and not significant.

regions (see table 1). We have eliminated from the sample all the regions without at least two consecutive years of information for all the variables, in order to apply a panel data methodology.

The empirical test has been carried out using data from different regional surveys taken from the Eurostat for the period 1996-2007. This data consists in an unbalanced panel data. That means that the number of observations per time period varies.

Table 1: Sample of European peripheral regions

Severozapaden (BG)	Attiki (GR)*	Guyane (FR)	Swietokrzyskie (PL)	Sud-Vest Oltenia (RO)*
Severen tsentralen (BG)	Notio Aigaio (GR)*	Reunion (FR)	Podlaskie (PL)	Vest (RO)*
Severoiztochen (BG)	Kriti (GR)*	Puglia (IT)*	Wielkopolskie (PL)*	Vzhodna Slovenija (SI)*
Yugozapaden (BG)*	Galicia (ES)*	Basilicata (IT)*	Zachodniopomorskie (PL)	Zahodna Slovenija (SI)*
Yuzhen tsentralen (BG)*	Asturias (ES)*	Calabria (IT)*	Lubuskie (PL)	Bratislavský kraj (SK)*
Praha (CZ)*	Cantabria (ES)*	Sicilia (IT)*	Dolnoslaskie (PL)	Západné Slovensko (SK)*
Strední Čechy (CZ)*	Pais Vasco (ES)*	Sardegna (IT)*	Opolskie (PL)	Stredné Slovensko (SK)*
Severovýchod (CZ)*	Navarra (ES)*	Cyprus (CY)*	Kujawsko-Pomorskie(PL)	Východné Slovensko (SK)*
Jihovýchod (CZ)*	La Rioja (ES)*	Latvia (LV)*	Warminsko-Mazurskie (PL)*	Itä-Suomi (FI)*
Strední Morava (CZ)*	Aragón (ES)*	Lithuania (LT)*	Pomorskie (PL)*	Etelä-Suomi (FI)*
Moravskoslezsko (CZ)*	Madrid (ES)*	Közép-Magyarország (HU)*	Norte (PT)*	Länsi-Suomi (FI)*
Estonia (EE)*	Castilla y León (ES)*	Közép-Dunántúl (HU)*	Algarve (PT)*	Pohjois-Suomi (FI)*
Border, Midlands and Western (IE)*	Castilla-la Mancha (ES)*	Nyugat-Dunántúl (HU)*	Centro (PT)*	Åland (FI)*
Southern and Eastern (IE)*	Extremadura (ES)*	Dél-Dunántúl (HU)*	Lisboa (PT)*	Stockholm (SE)*
Anatoliki Makedonia, Thraki (GR)*	Cataluña (ES)*	Észak-Magyarország (HU)*	Alentejo (PT)*	Östra Mellansverige (SE)*
Kentriki Macedonia (GR)*	Valencia (ES)*	Észak-Alföld (HU)*	Açores (PT)	Småland med öarna (SE)*
Dytiki Macedonia (GR)*	Baleares (ES)*	Dél-Alföld (HU)*	Madeira (PT)*	Västsverige (SE)*
Thessalia (GR)*	Andalucia (ES)*	Lódzkie (PL)*	Nord-Vest (RO)*	Norra Mellansverige (SE)*
Ipeiros (GR)*	Región de Murcia (ES)*	Mazowieckie (PL)*	Centru (RO)*	Mellersta Norrland (SE)*
Ionia Nisia (GR)	Canarias (ES)*	Malopolskie (PL)*	Nord-Est (RO)*	Övre Norrland (SE)*
Dytiki Ellada (GR)*	Corse (FR)*	Slaskie (PL)*	Sud-Est (RO)*	North Eastern Scotland (UK)*
Stereia Ellada (GR)*	Guadeloupe (FR)	Lubelskie (PL)*	Sud – Muntenia (RO)*	Highlands and Islands (UK)*
Peloponnisos (GR)*	Martinique (FR)	Podkarpackie (PL)*	Bucuresti – Ilfov (RO)*	Northern Ireland (UK)*

* In the final sample of 99 regions

Econometric Methodology

Firstly, we present the descriptive statistics and the correlation of the variables in the model, taken from the literature review presented in section 2. Furthermore, we analyze if the values of these variables are different between regions developing non-parametric Kruskal Wallis tests. We use a non-parametric test because we don't know the function distribution of data.

Secondly and based on the discussion of the previous section we present the following equation representing our empirical model, which is the panel data to be estimated for region i at time t :

$$LPATENT_{it} = a_i + b_1 LGDPpc + b_2 LPOP + b_3 LFTE S\&E + b_4 LPUBLIC R\&D EXP + b_5 LPRIVATE R\&D EXP + b_6 SPECIALIZATION + b_7 LUNIV R\&D EXP + u_{it}$$

Some of the variables have been taken in logarithms to develop the empirical analysis (PATENT, GDP, POP, FTE S&E, PUBLIC R&D EXP, PRIVATE R&D EXP, UNIV R&D EXP).

To estimate the model we use The Generalised Method of Moments (GMM) takes first differences and exploits a number of instruments in each time period (Arellano and Bond, 1991). To be specific, what is done here is to use the lagged values of exogenous variables as instruments in the GMM estimator. These have the feature of not being correlated with the individual effects (Arellano and Bond, 1998). The consistency of the GMM estimator depends on the validity of the instruments used. In order to address this issue we develop two specification tests. The first is the Sargan test (Sargan, 1958) of over-identifying restrictions, which tests the overall validity of the instruments by analyzing the moment conditions in the estimation process. Failure to reject the null hypothesis gives support to the model. The second test examines the hypothesis that the error term is not serially correlated. Specifically, we test whether the error term is first-order and second-order serially correlated.

Variables

The variables employed to evaluate the hypotheses put forward in this study were selected and constructed based on a review of the literature as well as the typology and availability of the data contained in the Surveys. The variables are summarized in table 2.

Table 2: Variables and definitions

Variable	Definition
Dependent variable	
PATENTS	Number of EPO patents granted by region
Independent variables	
<i>Quality of common innovation infrastructure</i>	
GDPpc	Gross domestic product per inhabitant in the region
POP	Population (millions of people)
FTE S&E	Number of full time equivalent scientists and engineers in all sectors
PUBLIC R&D EXPENDITURE	Total R&D expenditure funded by Government sector
<i>Cluster-specific innovation environment</i>	
PRIVATE R&D EXP	R&D expenditures funded by private industry
SPECIALIZATION	Relative concentration of Gross Added Value (GAV) of Agriculture, livestock farming and fishing, Energy, Industry, Building and Services GAV (thousands of €)
<i>Quality of linkages</i>	
UNIV R&D EXP	R&D expenditures performed by universities

4. Empirical results

Regional differences

Starting with the analysis of regional differences in terms of the variables in the empirical model, we have developed non-parametric Kruskal-Wallis tests in order to know if those differences are statistically significant. For all cases differences between regions are statistically significant at level 0.01. This result suggests the existence of difference between regions regarding to its innovative activities and the main factors supporting them. These differences could be determined by the specific regional characteristics as well as by the diversity of regional innovation policies in Europe due to the decentralization.

Correlations

As far as correlations is concerned table 3 shows that PATENTS is positive and significantly correlated to all the variables from the Furman et al. (2002) approach with the exception of three variables from the cluster-specific innovation environment (SPEC_IND; SPEC_BUILD; SPEC_SERV). These results suggest that the Quality of

the Innovation Infrastructure, the Cluster-specific environment and the Quality of Linkages have a positive effect on regional innovative capacity. This conclusion proves the adaptability of the Furman et al. (2002) model at regional level.

Regression results

In this section we present the results obtained in the GMM estimation that are summarized in table 4. We present the results organized in based on the dimensions of the model (the quality of the common innovation infrastructure, the cluster-specific innovation environment and the quality of linkages)

1. The quality of the common innovation infrastructure

Starting with the variables within the “Quality of the common innovation infrastructure” the variables LGDP and LFTE S&E have a negative effect on regional innovative capacity that is only significant for the case of the first variable (LGDP). These results are in contrast with the main previous empirical literature. Regarding to the variable LPOP, it has a positive and significant effect on regional innovative capacity as in previous papers (Hu and Mathews, 2008; Krammer, 2009). Finally, the variable LPUBLIC R&D EXPENDITURE has a positive and significant effect on regional innovative capacity, which is in line with previous literature (Furman et al., 2002; Gans and Stern, 2003; Furman and Hayes, 2004; Hu and Mathews, 2005; Krammer, 2009).

2. The cluster-specific environment

Regarding to the variables within the cluster-specific environment LPRIVATE R&D EXPENDITURE has a positive and significant effect as in Furman et al. (2002), Gans and Stern (2003), Riddel and Schwer (2003), Furman and Hayes (2004), Hu and Mathews (2005), Hu and Mathews (2008) and Krammer (2009). Finally, in terms of industry specialization the study suggests that regions with

high levels of specialization in energy (SPEC_ENER) and services (SPEC_SERV) has high innovative capacity.

3. The quality of linkages

As far as the quality of linkages is concerned the results suggest the positive effect of the variable LUNIV R&D EXP on regional innovative capacity which is line with previous research (Furman et al., 2002; Gans and Stern, 2003; Furman and Hayes, 2004; Hu and Mathews, 2008; Krammer, 2009).

Finally, the last section of table 4 presents the Sargan test of overidentifying restrictions as well as tests for first order (AR(1)) and second order (AR(2)) serial correlation tests of the first-differenced residuals. The latter are consistent with the assumption of no serial correlation in the residuals⁶. The Sargan test accepts the null hypothesis of valid instruments, indicating the validity of the instruments and the estimation.

⁶ In order to obtain consistent GMM estimates the assumption of no serial correlation in the residuals in levels is essential. This assumption holds if there is evidence of significant and negative first-order serial correlation and no evidence of second-order serial correlation in the first-differenced residual (Arellano and Bond, 1998).

Table 3: Descriptive statistics and correlations

	Mean	St. deviation	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
PATENTS	44.114	110.019	1											
GDPpc	13135.530	8474.124	0.539***	1										
POP	2060286	1551002	0.249***	-0.0665	1									
FTE S&E	6265.173	7807.566	0.674* **	0.3720***	0.6457***	1								
PUBLIC R&D EXPENDITURE	47.987	96.116	0.5600***	0.3900***	0.5109***	0.8948***	1							
PRIVATE R&D EXP	172.770	391.006	0.885***	0.624***	0.299***	0.772***	0.706***	1						
SPEC AGR	0.061	0.044	0.2317***	0.3352***	0.0166	0.1915***	0.0784***	-0.213***	1					
SPEC ENERG	0.228	0.090	0.0761*	0.219***	0.031	0.023	0.031	0.066	0.043	1				
SPEC IND	0.301	0.087	0.0666	-0.1498***	-0.0047	0.0407	-0.0200	0.0792*	0.0238	0.967***	1			
SPEC BUILD	0.073	0.022	-0.047	0.296***	0.125***	0.054	0.042	0.036	-0.043	-0.245***	-0.001	1		
SPEC SERV	0.638	0.099	0.043	0.279***	0.001	0.045	0.049	0.022	-0.454***	-0.873***	-0.897***	0.028	1	
UNIV R&D EXP	3.281	125.131	0.7458***	0.6316***	0.5303***	0.7761***	0.6997***	0.8384***	-0.2134***	-0.0890***	-0.0409	0.1877***	0.1271***	1

* Significant at 0.1 ** Significant at 0.05 *** Significant at 0.01

(a) Non-parametric Kruskal-Wallis test have been Developer for all the variables, and in all the cases differences between regions at significant at 0.01

Table 4: Determinants of regional innovation capacity

	GMM estimation
Quality of the common innovation infrastructure	
LGDPpc	-1.423 (0.456)***
LPOP	1.994 (2.457)***
LFTE S&E	-0.129 (0.134)
LPUBLIC R&D EXPENDITURE	0.461 (0.076)***
Cluster-specific innovation environment	
LPRIVATE R&D EXP	0.268(0.046)***
SPEC AGR	6.088 (5.267)
SPEC ENER	13.610 (3.987)***
SPEC IND	Reference variable
SPEC BUILD	Reference variable
SPEC SERV	12.007 (4.618)***
Quality of the linkages	
LUNIV R&D EXP	0.023 (0.129)
Specification and validity test	
Sargan test	98.55 (0.090)
AR(1)	-2.28 (0.023)
AR(2)	-0.95 (0.344)

*p<0,1

** p<0,05

*** p<0,01

Standard errors (in brackets) are reported next to the coefficient estimates

5. Conclusions

This paper has developed a double purpose. On the one hand, we have analyzed if the model of Furman et al. (2002) can be useful at regional level. On the other hand, we have studied the determinants of the innovative capacity in European peripheral regions applying the abovementioned model.

The conclusions can be summarized in two main groups: 1) conclusions of the research and 2) managerial implications for innovation policy.

Conclusions of the research

In model of Furman et al. (2002) the authors identified three main dimensions that should be taken as drivers of innovative capacity: the quality of common innovation infrastructure, cluster-specific innovation environment and the quality of linkages. Our empirical results, which are in line with previous empirical papers, show the importance of some factors related to the quality of common innovation infrastructure and the cluster-specific innovation environment on the regional innovative capacity. However,

the quality of linkages doesn't seem to have a significant effect on regional innovative capacity. Starting with the common innovation infrastructure the main important indicators on determining the innovative capacity are the population and the public spending on R&D. Following with the cluster-specific innovation environment the empirical results show the importance of the private spending on R&D and the specialization in industry and specialization in services. Finally, as far as the quality of linkages is concerned, although the results suggest a positive effect it cannot be statistically confirmed.

Managerial implications for innovation policy

As far as managerial implications is concerned we focus on those for public administration officials for the design of the innovation policies.

The results of our study allow us to know the factors that determine the regional innovative capacity, which could be of interest to improve the policies supporting innovation activities of regions.

The main recommendation derived from the study is that some factors related to the quality of the common innovation infrastructure and the cluster-specific environment must be considered in the design of the innovation policies. In this line, we recommended to develop public programs of investment on R&D or supporting the private R&D activities in the industrial sectors, on the one hand. On the other hand, public support to the industrial and service sectors in their innovative activities could also implied more regional innovative capacity.

Limitations and future research

The principal limitation of this study derives from the data available, which has conditioned the selection and the manner in which we constructed some of our variables.

In terms of future research, it would be worthwhile to obtain additional empirical evidence that would provide conclusive results regarding the regional differences using most robust statistical analysis than the descriptive ones used here.

6. References

Acosta, M. and Coronado, D. (1999), “Innovación Tecnológica y Desarrollo Regional”, *Información Comercial Española Octubre*, Vol. 781, pp. 103–116.

Aghion, P. and Howitt, P. (1992), “A Model of Growth Through Creative Destruction”, *Econometrica*, Vol. 60, pp. 323-351.

Arellano, M., Bond, S. (1991), “Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations”, *Review of Economic Studies*, Vol. 58 No. 2, pp. 277–297.

Arellano, M., Bond, S. (1998), *Dynamic Panel Data Estimation Using DPD98: A Guide for Users*. University of Oxford mimeo.

Arrow, K. J. (1962), “The Economic Implications of Learning by Doing”, *Review of Economic Studies*, Vol. 29, pp. 155-173.

Baumert, T. and Heijs, J. (2002), “Los determinantes de la capacidad innovadora regional: una aproximación econométrica al caso español. Recopilación de estudios y primeros resultados”, documento de trabajo No. 33, Instituto de Análisis Industrial y Financiero, Universidad Complutense, Madrid (www.ucm.es/BUCEM/cee/iaif).

Buesa, M, Heijs, J., Martínez Pellitero, M. and Baumert, T. (2006), “Regional systems of innovation and the knowledge production function: the Spanish case”, *Technovation*, No. 26, pp. 463-472.

Chatterton, P. and Goddard, J. (2000), “The Response of Higher Education Institutions to Regional Needs”, *European Journal of Education*, No. 35, Vol. 4, pp. 475-496.

Denison, E. F. (1962), "United States Economic Growth", *Journal of Business*, Vol. 35, pp. 109-121.

Denison, E. F. (1967), *Why Growth Rates Differ: Post-War Experience in Nine Western Countries*, Brookings Institution, Washington, D. C.

Dosi, G. (Ed.) (1988), *Technical change and economic theory*, Pinter Publishers, London, UK.

Edquist, C. (1997), *Systems of Innovation: Technologies, institutions and organization*, Pinter Publishers, London, UK.

Fagerber, J. (1987), "A technology gap approach to why growth rates differ", *Research Policy*, Vol. 16, pp. 1571-1583.

Fagerberg, J. (1988), "Why growth rates differ", G. Dosi et al. (Eds.), *Technical Change and Economic Theory*, Pinter, London, pp. 432-457.

Fagerberg, J. (1991), "Innovation, catching up and growth", *Technology and Productivity: the Challenge for Economic Policy*, Paris: OECD, pp. 37-46.

Fagerberg, J., Mowey, D. C. And Nelson, R. R. (2006) (Eds.), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford.

Furman, J. L., Porter, M.E. and Stern, S. (2002), "The determinants of national innovative capacity", *Research Policy*, Vol.31, pp. 899-933.

Furman, J. L. and Hayes, R. (2004), "Catching up or standing still? National innovative productivity among 'follower' countries, 1978-1999", *Research Policy*, Vol. 33, pp. 1329-1354.

Gans, J. and Stern, S. (2003), "Assesing Australia's innovative capacity in the 21st century", Working Paper 2003-16, Melbourne Business School.

Gregersen, B. and Johnson, B. (1997), "Learning economies, innovation systems and European integration", *Regional Studies*, Vol. 31, pp. 479-490.

Grossman, G. M. and Helpman, E. (1991), *Innovation and Growth in the Global Economy*, Cambridge, MA: MIT Press.

Hu, M-C. and Mathews, J.A. (2005), “National innovative capacity in East Asia”, *Research Policy*, Vol. 34, pp. 1322-1349.

Hu, M-C. and Mathews, J.A. (2008), “China’s national innovative capacity”, *Research Policy*, Vol. 37, pp. 1465-1479.

Jones, C. (1988), *Introduction to the Economic Growth*, WW Norton&Co., New York.

Krammer, S.M.S. (2009), “Drivers of national innovation in transition: evidence from a panel of Eastern European countries”, *Research Policy*, Vol. 38, pp. 845-860.

Lucas, R. E. (1988), “On the mechanisms of the Economic Development”, *Journal of Monetary Economics*, Vol. 22, pp. 435-444

Meyer-Kramer F (2001), “Industrial innovation and sustainability—conflicts and coherence”, Archibugi D, Lundvall BÅ (Eds.), *The globalizing economy*, Oxford University Press, Oxford, pp 177–194.

Nelson, R. R. (1993) (Ed.), *National Innovation System: A comparative analysis*, Oxford University Press, New York.

Nelson, R. R. and Winter, S. (1982), *An evolutionary theory of economic change*, Harvard University Press, Cambridge.

Park, S-C. , Lee, S-K. (2005), “The national and regional innovation systems in Finland: from the path dependency to the path creation approach”, *AI & Society*, Vol. 19 No. 2, pp. 180-195.

Porter, M. (1990), *The Competitive Advantage of Nations*, Free Press, New York.

Riddel, M. and Schwer, K. R. (2003), “Regional innovative capacity with endogenous employment: empirical evidence from the U.S”, *The Review of Regional Studies*, Vol. 33 No. 1, pp. 73-84.

Romer, P. (1986), "Increasing Returns and Long Run Growth", *Journal of Political Economy*, Vol. 94, pp. 1002-1037.

Romer, P. (1987), "Growth based on increasing returns due to specialization", *American Economic Review*, Vol. 77, pp. 56-62.

Romer, P. (1990), "Endogenous technological change", *Journal of Political Economy*, Vol. 98, S71-S102.

Sargan, D.J., (1958), The estimation of economic relationships using instrumental variables, *Econometrica*, Vol. 26, No. 3, pp. 393-415.

Solow, R. (1956), "A contribution to the theory of economic growth", *The Quarterly Journal of Economics*, Vol. 70 No. 1, pp. 65-94.

Solow, R. (1957), "Technical change and the aggregate production function", *The Review of Economics and Statistics*, Vol. 39 No. 3, pp. 312-320.

Varsakelis, N. C. (2006), "Education, political institutions and innovative activity: a cross-country empirical investigation", *Research Policy* Vol. 35, pp. 1083-1090.

Verspagen, B. (2000), "Economic growth and technological change: an evolutionary interpretation", OECD STI Working Papers, NO. JT00101276.

Wooldridge, J. F. (2002), *Econometric analysis of Cross-section and Panel-data*, MIT Press, Cambridge, MA.