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The determinants of regional innovation in Europe: A combined factorial and regression knowledge production function approach☆

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ABSTRACT

The present paper studies the determinants of regional innovation in Europe through a knowledge production function approach that combines factorial analysis and regression. Our dependent variable are the patents while we used initially 21 explanatory variables that were converted—by a factor analysis—into five non-observable "hypothetical" variables reflecting five important aspects of the innovation systems: the National environment, the Regional environment, Innovating firms, Universities and the R&D done by Public Administration. Our results show that all factors have a statistically significant effect on the production of knowledge (patents), although they present very different impacts.

1. Introduction

Technological innovation has become a crucial factor of competitiveness. Thus, innovatory capacity is a critical factor for the European Union's economic growth, especially if we take into consideration that an important part of productive growth in advanced nations—as measured in terms of Gross Domestic Product—[1] corresponds to innovation (Freeman, 1994), so we may consider it to be one of the key factors of competitiveness, business survival, growth and employment (Cooke et al., 2000:1; Cooke, 1998:vii; OCDE, 1999:3). Thus it is especially important to find out what components of an R&D system are most decisive as engines of innovation and what are the factors determining systems' innovatory capacity. As Edquist (2005:201), points out, "given our limited systematic knowledge about determinants of innovation [. . .] case studies comparing innovation systems of various kinds as well as the determinants of innovation processes within them [. . .] have great potential". Consequently, these questions have particularly captured the attention of academic researchers and those with political responsibilities throughout recent decades.[2] This has given rise to a series of important studies, both theoretical and empirical.[3] And it is these questions which we will attempt to answer in the present work for the case of European regions, starting for this purpose from an approach that combines different theoretical streams. Following the approach of Furman et al. (2002) our analysis is also based on the ideas driven endogenous growth theory (Lucas, 1988; Romer, 1990); the cluster bases theory of national competitive advantages (Porter, 1990 and, more specifically, 1998) and the concepts of the national and regional innovation system (Freeman, 1987; Lundvall, 1992; Nelson, 1993; Cooke and Morgan, 1994). Based on this literature and theoretical concepts a broad range of determinants or explanatory factors of the production of new ideas or knowledge could be defined. From the work of Romer we apply the idea that the production of knowledge requires specific investments in R&D and the important role of human capital. Taking into account the competitive advantages of Porter we include

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[1] See, among others, the contributions of Romer (1990), Jones (1995) and De La Fuente (2003).

[2] We found an interesting precedent in Ewers and Wettmann, who, as long ago as 1980, devoted a section of their study to "Determining factors of regional innovative potential". The authors highlight two factors as significant: the potential for action of regional economic units—which will depend on their internal characteristics—and the interaction of these units with their environment and among themselves.

[3] A short review of the results of those studies are presented later on in this paper.

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in our analysis specific aspects of the regional and national context of the innovation process. The innovation systemic approach underpins—besides the already mentioned national and regional context—the institutional framework and the fact that its outcome depends on a broad heterogeneous number of aspects. Therefore the systemic approach induces us to work with a factor analysis that permits the use of a broad number of interdependent correlated explanatory variables. Moreover the systemic approach considers the determinants as interdependent and highlights the difficulty to classifying them between causes and consequences. For example successful firms, Universities and other public research organisations do coincide normally in the same regions (Nelson, 1993) and also industries develop in regions that offer qualified human capital and R&D services (Freeman, 1994), however it is not clear who induces who. In such a system in which all factors and agents do influence each other it is impossible to use the traditional econometric models based on individual variables. For all these reasons we developed a new procedure in this type of research, by combining the regression of the *knowledge production function* (*KPF*)—initially developed by Griliches (1979)—with the factorial analysis in line with the predecessor of Bania et al. (1992).

The main aim of this paper is the development of a new more holistic approach using a broad set of variables to analyse the determinants of the production of knowledge, that helps us to demonstrate empirically that an innovation system consists of multiple, interrelated elements and each of them have a certain impact on the innovative results of the region. Like argued before, this approach is inherent to the evolutionary theory that underpins that the innovative performance has to be considered as a multidimensional activity. The literature emphasises the difficulty and the weakness of the use of individual indicators to measure the global concept of innovation (like patents, R&D expenditures, percentage of sales related to new products, etc.). Each of those indicators—although highly correlated—gives a different view of apparently the same subject.[4] It is worthwhile treating the concept and the different elements of an innovation system as something which is not directly observable. In this case by means of a multivariate methodology and despite the statistical limitations always to be found in these topics, in this paper we create and describe a series of hypothetical variables registering the most important relationships related to technological change. For the creation of "combined" indicators that reflect the different aspects of the regional innovation systems we used a *factor analysis*. This technique allows us to reduce the a broad set of existing variables to a lower set of non-observable hypothetical variables, called factors, which summarise practically all the information contained in the original set. From our point of view these new synthetic variables or factors better reflect the general aspects of the regional innovation systems than could be done by each of the individual variables included in the factor.

As stated by Fritsch (2002:20) "[. . .] the knowledge production function is quite useful for comparing the quality of regional innovation systems [. . .]". In the present paper we estimate such a production function in order to study the determinants of regional innovation in Europe using an approach that combines factorial analysis and regression. Our dependent variable are patents while we initially used 21 explanatory variables that were converted—by a factor analysis—into five non-observable "hypothetical" variables (factors) representing five main aspects of the innovation systems: the National environment, the Regional environment, Innovating firms, Universities and the R&D done by Public Administration. Our results show that all factors and their interactions are statistically significant, though they present very different impacts.

2. Patents as a measurement of innovation

In line with our previous studies on the subject,[5] we chose to use as dependent variable—that is, as innovation measurement—the number of patents registered in the European Patents Office (EPO), as recorded on the EUROSTAT REGIO database, given that—compared to what happens in national patents offices—the patents registered by the EPO have the advantage of avoiding the problems of the "headquarters" effect,[6] since they are allocated to the inventor's place of residence.

There is a broad debate on the appropriateness of the patents to measure the production of knowledge,[7] however, up to now, there are very few alternatives to this variable. A priori, it could be said that the best measurement of innovation is given by the number of innovations which have been commercialised. For the moment, the main limitation to this variable is imposed by the almost total unavailability of data (the data collected refers only to the income due to innovations). Moreover this measurement would also present a series of disadvantages which cannot be ignored. A source of data could be—in the future—the European Innovation Survey, though, the information from such a survey would be sensitive to the rate of response, to the interpretation firms put on the term innovation, the possible bias—especially in the case of regional data—due to the "headquarters effect" and the average life cycle of products in the firms consulted (Kleinknecht et al., 2002:114–115). Against that, patents and their evaluation process are "objective". Another disadvantage to be borne in mind is that the introduction of a new product on to the market takes place in the final phase of the innovation process, in a moment which could be a long way from that when the supply took place, a measurement usually made via the R&D effort (Schmoch, 1999:113). In the case of patents, on the other hand, the relationship with R&D is almost contemporaneous (OCDE, 2004a:139).

Now, what is the exact relationship between patents and innovations, and how high is the probability of a patent becoming an innovation? Several authors have attempted to reply to this question, with varying results. Acs and Audretsch (1988) calculated that the ratio between patents and innovation might vary substantially on the basis of the industrial sector, from an average 49 per cent to 0.6 per cent. Later on, the European Patents Office estimated that only 50 per cent of innovations were patented (OEP, 1994:25), although authors such as Schmoch (1999:114) pointed out that this value was too low. More recently, Arundel and Kabla have estimated an average 33 per cent for patents/innovations in the case of products and 20.1 per cent in the case of services (Arundel and Kabla, 1998:133), with strong swings detected between the different industrial sectors. Thus, in the pharmaceutical sector, 79.2 per cent of product innovations are patented, whereas in the case of textiles this percentage does not go beyond 8.1 per cent. Also on this occasion the criticism made by Schmoch of the estimate of the European Patents Office is valid: the real values have to be higher

[4] For example in 2005 the technological level of Spain in comparison with the European Union (EU-15 = 100) was 45 per cent taking into account the R&D expenditures by GNP; 62 per cent in the case of employment in R&D by total employment; and 15 per cent using the number of patents per capita.

[5] See Baumert and Heijs (2002) and Buesa et al. (2003a,b, 2005).

[6] This effect consists of the underestimation of the number of innovations of the regions where a R&D performing branch of a large firm is located, because their innovations are often patented by its headquarter and therefore are not included in the official statistics the region where the headquarter is located.

[7] See among others Griliches (1990), Pavitt (1985, 1988), Mansfield (1986), Trajtenberg (1990), Archibugi (1992), Schmoch (1999), European Commission (2001:38) and Smith (2005:158–160).