Quality of academic scientific research across Europe. Is it all about money?

(Extended abstract)

Theme: Overall performance of the Triple Helix approach: From efficiency of factors of production to 'modes of coordination'.

Keywords: research funding, research quality, citations, knowledge production function, R&D funding.

JEL Classifications: O31; R10; R15.

1. Introduction

The Triple Helix highlights the importance of interactions between University, Government and Industry. This paper is focused on the links between two of these spheres (University-Industry) by examining the effect of public R&D funding on the quality of academic scientific research. Large amounts of public funds are yearly devoted to academic research, basing on the assumption that research funding enhances research performance. In this regard, there is some evidence of the short-term usefulness of R&D incentives at country level to promote scientific research (Adams & Griliches, 1998; Crespi & Geuna, 2008), but there is little evidence at regional level. We argue that regional scale is also relevant for several reasons. First, there is large empirical evidence on the importance of academic knowledge in regions since it may potentially impact on regional economic development. Second, from a political viewpoint many European regions enjoy a high degree of self-government, and they have also been

assigned a role in achieving the objectives of the European Research Area (ERA) (see European Commission, 2001) and developing research and innovation capacity in Europe. In this regard, funding mechanisms, among others, are considered relevant instruments, in shaping quantity and quality of research (de Dominicis et al., 2011).

The paper is organized as follows. Section 2 summarizes the literature relevant to this paper. Section 3 describes the methodology. Section 4 presents the results. Section 5 includes the conclusions and a brief discussion of policy implications.

2. Literature review

This literature review is organized around two questions relevant to this paper:

-Why is scientific research important?

-What is the effect of R&D funds on scientific output?

Regarding the first issue, the flow of knowledge has important potential benefits for regions because of spillovers from university to industry affecting not only technology but other relevant variables for the economic system (Anselin et al., 1997; Anselin et al., 2000; Jaffe, 1989; Jaffe et al., 1993; Maurseth & Verspagen, 2002; Verspagen & Schoenmakers, 2000). We expect this effect to be larger the greater quantity and quality of university research output.

With respect to the second issue, the main lesson from this empirical literature is that money helps to achieve a better research performance both in terms of quantity and quality (for a review, see Acosta, et al. 2012). However, difficulties in obtaining accurate data prevent from estimating reliable university R&D effects (elasticities), although most of the analyses found decreasing returns to university R&D expenditure.

In order to contribute to this empirical literature, we address a number of related empirical questions in the following sections:

1. What are the effects of academic R&D funding in promoting the quality of scientific research at regional scale?
2. Is there any difference according to the level of regional development?

3. Methodology

To evaluate the impact of R&D expenditures on science production, we estimate a regional version of the knowledge production function suggested by Adams and Griliches (1996) in terms of inputs and outputs. The inputs are academic R&D funds; the outputs are citations. The empirical panel model takes the form:

$$\ln SP_{it} = \beta \ln RD(r)_{it} + \delta RS(r) + \alpha_i + \eta_t + u_{it}$$

where the dependent variable $\boldsymbol{SP_{it}}$ account for the number of citations received by the publications of region *i* in year *t* (both, total number of citations and citations per paper). The explanatory variables are as follows:

- **lnRD(r)** is the logarithm of past R&D expenditure (since it takes time for R&D to be reflected in scientific output). In our models, academic R&D expenditure is proxied using R&D expenditure in the Higher Education Sector (HERD) from Eurostat (in millions of Purchasing Power Standard –PPS- at 2000 prices).

- **RS.** It is expected that regions with a large participation in fields with high propensity to publish or to be cited produce more outputs. Therefore, this variable controls for the weight that each scientific field has in the number of forward citations.

- **α** represents regional specific effects (e.g. cultural practices, regional demand of research).

- **η** captures time effects.

- ***u*** is a disturbance term.

In this paper, we estimate random effects models because of several reasons. First, we count on an unbalanced panel in which R&D funds present very little variance year by year; second, the dependent variable presents unsteady fluctuations year by year. In these cases, we are forced to use random effects estimation in order to learn anything about the population parameters (Wooldridge, 2002 p. 286).

4. Data

The data used in this study consists of a set of university 994,938 scientific papers published in scientific journals indexed by the Science Citation Index Expanded (SCI), which we have classified into 213 NUTS2 regions and 12 scientific disciplines. The dataset used in this study has been previously used in Acosta *et al.* (2011) and Acosta *et al.* (2012) (see these publications for more details about this dataset). As is well known,

the SCI is a bibliographical database produced by the Information Sciences Institute (ISI), which is part of Thomson Reuters' Web of Science.

5. Results

We estimated two sets of models. First, we included the logarithm of citations as dependent variable. However, we are aware that the total number of citations to the publications of a region is expected to increase as the number of publications increases and R&D funds have been shown to have a positive effect on the number of publications (Acosta *et al*, 2012). Therefore, we also estimated a second set of models using the number of citations per paper as dependent variable. Results are shown in Table 2. Additionally, we estimated the same models, but including population as control variable in order to account for differences in the size of regions (Table 3).

We have identified some regularities:

- When including the number of citations (in log) as the dependent variable, we observe a positive and significant effect of academic R&D in both types of regions. The time lag and magnitude of this effect is greater in Objective-1 regions than in developed regions.

- From the models using the number of citations per paper, we obtained a positive and significant effect of R&D funds in non-Objective-1 regions, while a negative but not significant coefficient was found in less developed regions.

These results still hold after including population as control variable (Table 3). It is remarkable that a positive effect of R&D funds on the relative quality of research is only found in developed regions.

5. Conclusions

This paper is mainly aimed at evaluating the role of academic R&D funds in encouraging the quality of scientific production. For this purpose, we estimated a knowledge production function using random effect models. We found the following results:

- In absolute terms (using number of citations as dependent variable):
    - R&D funds promote the quality of academic science across European regions in both developed and Objective-1 regions. This can be explained because R&D funds promote the quantity of scientific output (Acosta *et al*. 2012), and the probability of a region to be cited increases as its number of papers increases. However, as in previous research, decreasing returns to scale were found in all the estimated models.

    - A positive effect differs across regions depending on their level of economic development. It occurs with greater time lag and larger magnitude in Objective-1 regions than in developed regions. These results are in line with those obtained for the models of quantity by Acosta *et al*. (2012). They argued that these differences may be due to more suitable conditions for research in non-objective regions and a lower starting point of objective-1 regions, respectively.

- In relative terms (using citations per paper as dependent variable)
    - R&D funds foster the quality of scientific publications in developed regions, but not in Objective-1 regions. This maybe the result of a negligible effect of R&D funds on the quality of the research or the need to consider a longer time lag for Objective-1 regions.

Our findings have some implications for science policy in Europe. On the one hand, in absolute terms, there is a positive effect of academic R&D funding on the quality of the research in both types of regions. However this effect is time lagged, especially in Objective-1 regions. This should be taken into consideration by policy makers when designing science policy. On the other hand, the effects of academic R&D funds on the quality of the research in relative terms differ among regions according to their level of economic development. Increasing levels of R&D funds result in higher quality scientific output in developed regions, but not in Objective-1 regions.

Nevertheless, more evidence about the effect of academic R&D funds on the quality of scientific research in relative terms. Future research could be developed analysing longer time lags.

References

Acosta, M., Coronado, D., Ferrándiz, E., & León, M. D. 2011. Factors affecting inter-regional academic scientific collaboration within Europe: the role of economic distance. ***Scientometrics***, 87(1): 63-74.

Adams, J. D., & Griliches, Z. 1998. Research Productivity in a System of Universities. ***Annales d'Economie et de Statistique***(49-50): 127-162.

Anselin, L., Varga, A., & Acs, Z. 1997. Local geographic spillovers between university research and high technology innovations. ***Journal of Urban Economics***, 42(3): 422-448.

Anselin, L., Varga, A., & Acs, Z. J. 2000. Geographic and sectoral characteristics of academic knowledge externalities. ***Papers in Regional Science***, 79(4): 435-443.

Crespi, G. A., & Geuna, A. 2008. An empirical study of scientific production: A cross country analysis, 1981-2002. ***Research Policy***, 37(4): 565-579.

de Dominicis, L., Elena Pérez, S., & Fernández-Zubieta, A. 2011. European university funding and financial autonomy. A study on the degree of diversification of university budget and the share of competitive funding., ***Scientific and Technical Research series***. Luxembourg: Publications Office of the European Union.

European Commission. 2001. The Regional Dimension of the European Research Area. Brussels: Commission of the European Communities.

Jaffe, A. B. 1989. Real effects of academic research. ***American Economic Review***, 79(5): 957-970.

Jaffe, A. B., Trajtenberg, M., & Henderson, R. 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. ***Quarterly Journal of Economics***, 108(3): 577-598.

Maurseth, P. B., & Verspagen, B. 2002. Knowledge Spillovers in Europe: A Patent Citations Analysis. ***Scandinavian Journal of Economics***, 104(4): 531-545.

Verspagen, B., & Schoenmakers, W. 2000. The Spatial Dimension of Knowledge Spillovers in Europe: Evidence from Firm Patenting Data. The Netherlands: Technische Universiteit Eindhoven.

Wooldridge, J. 2002. ***Econometric Analysis of Cross Section and Panel Data***. Cambridge: MIT Press.