FOOD SCIENCE AND TECHNOLOGY ACROSS EUROPE 15. SCIENTIFIC KNOWLEDGE BASE AND DIFFERENCES IN QUALITY*

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Abstract
This paper contributes with some insights into scientific knowledge base in food industry at the regional level in Europe 15. We argue that science production by universities is not enough to create a scientific knowledge base. An additional requirement is counting on some standards of quality for being useful to firms. We explore this line of inquiry by first examining the regional distribution of food science across Europe and its relationship with the production of technology in the European food industry and then by focusing on the role of quality of FS&T and its determining factors. The methodology relies on rolling correlation and panel data models. Our sample consists of about 13 thousand papers in the field of "Food Science & Technology" (FS&T), covering the period from 1998 to 2004. The results show that only regions with high-quality published papers on food science present a significant relationship with the production of food technology. Furthermore, funding, research tradition and specialization are the main factors affecting the quality of FS&T, while the demand for science from the region does not play any role. The paper concludes with some policy implications for strengthening the regional knowledge-base economy in the food industry.

Keywords: Food science, Food industry, Knowledge-base, Citations, Patents.

Introduction

Food industry needs to use science to increase competitiveness and satisfy the consumer demands, but at the same time the sector does not rely much on investments in R&D. This might seem paradoxical. On the one hand, the European food and drink sector presents very low investment in R&D (only 0.53% of turnover), which is probably consequence of the special characteristics of food companies; most of them are small firms that may lack the scientific, engineering and management know-how to produce or commercialise their own technology (Fryer and Versteeg, 2008). On the other hand, the sector has to deal with the challenges to develop new technologies for producing safer, healthier and more nutritious products, using less chemicals and taking care of the environment (Rollin et al., 2011)). One way to balance the lack of own R&D investment and the need of maintaining the sector competitive is strengthening its scientific knowledge base through the acquisition and assimilation of science produced in universities. This approach to universities has in many cases occurred naturally from the demand side for knowledge (firms set up close to universities to take advantage of spillovers). Sometimes regional governments have tried to reinforce the links between university and industry acting from the supply side by investing more and more in the hope that universities produce not only new knowledge but also contribute more directly to the economies of the regions in which they are located.

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This paper aims to shed light on the regional scientific knowledge base in food industry across Europe 15 and its quality by analyzing the regional distribution of science in the field of Food Science and Technology FS&T. As other so-called low-tech sectors, food industry is intensive in their use of scientific knowledge, however, the depth and complexity of industry knowledge bases are not linked to their indirect R&D performance (Smith, 2002). Therefore, we claim that a better way to determine the scientific knowledge base in food industry is through the output of the research instead of using the R&D expenditure. However, the production of a quantitative large amount of science (measured by the number of scientific publications) in a region is insufficient to set up a "scientific knowledge base". The science system must provide useful inputs for solving technological problems and must be transferred to the industry. In this paper we claim that science production is not enough; it must fulfill an additional requirement: scientific production needs some standards of quality for being useful for firms. The paper provides some insight into this topic for European regions. First we have identified the spatial distribution of scientific knowledge in food sector and examine the links between science and technology. Next we address the factors affecting the quality of the food science. Both aspects are unknown at this spatial scale of analysis and the paper fills these gaps.

To further clarify the objective of the paper, it should bear in mind that knowledge-based economies can be defined as: ''economies which are directly based on the production, distribution and use of knowledge and information'' (OECD, 1996, p. 3), which means that identifying the knowledge-base of any sector is much more than analyzing the scientific or technological support. Innovative activities have much broader knowledge basis than just science or technology. From a regional point of view, a region's knowledge base is larger than its science base (Asheim, 2012). This means that this research is limited to that part of the knowledge-base related to the scientific support, which implies that much more research is necessary to fully understand all the factors and mechanisms involved in the knowledge base creation and acquisition in the food sector.

The methodology consists of some descriptive measures and the estimation of several panel data models. By drawing upon a sample of about 15 thousand papers in the field of "Food Science & Technology" (FS&T) covering the period from 1998 to 2004, our results show, firstly, that only regions with high-quality published papers on food science present a significant relationship with the production of food technology. Secondly, funding, research tradition and specialization are the main factor affecting the quality of FS&T, while the demand for science from the some region where it is produced does not play any relevant role.

The paper is organized as follows. The next section summarizes the literature relevant to this paper. Section 3 describes the empirical framework, defining the way in which we obtain the regional relationship between science and technology and putting forward a panel data model to identify the factor affecting scientific quality. Section 4 explains the data. Section 5 discusses the three key results of the papers: scientific knowledge base, the regional science-technology relationship and the factor determining the quality of science in European regions. We briefly summarize the conclusions, policy implications in the final section.

1. Literature review

Despite the widespread belief that knowledge-base economy is tied to the development of high technology, food and drink industry –classified as low tech for its relative low levels of internal R&D– is intensive in the use of scientific inputs as recent research has recently shown (e.g. Acosta et al., 2011, Muscio, 2012). The need to rely on food science arises from a range of benefits to both demand (consumers) and supply side (food industry). Scientific advances in biotechnology and nanotechnology have been used to support many innovations recently, including those in food sectors (see, for example, the papers by Carew, 2005; Kalpana Sastry et al., 2009). Some processors, facing saturated markets for traditional foods, have moved to new high value products that have the common characteristic of benefiting from advanced technology in biotechnology, chemicals and drugs (Alfranca et al., 2004). Such scientific fields offer more robust, safer, longer lasting, cheaper and smarter products that will have many applications in the household, communications and medicine as well as in agriculture and the food industry (Hosseini, 2009). These new scientific advances and technologies with potential applications to the food industry can boost production at lower prices and increase supply. They also assure many benefits for consumers. Scientific knowledge offers great opportunities to change and improve the taste of products, preparation and nutritional characteristics (Muscio et al., 2010, 2012) but many of these changes also constitute new challenges to the safety of the food supply (Hoffman, 2010).

At the same time, science development and its transfer to food industry have not only microeconomic implications. The changes that concern the use of scientific breakthroughs in food sectors have noticeable effects on relevant social variables. A considerable number of studies have shown that science and research scientific programs in all sectors related to food can reduce poverty (along with increasing productivity and competitiveness), provide food security and other benefits (Alene, 2009; Alston et al., 1995, 2002; Pingali and Traxler, 2002; Smale, 2007). From a political view, there are also implications. Regional governments confront the European Paradox, especially important in food industry, where innovations are increasingly supported by scientific research in fields such as biotechnology or chemicals in which there is high scientific performance, but little contribution to improved technological development. The research in this field has prompted measures for a better organisation of policy instruments or the innovation system in a variety of contexts (see, for example, Arias-Aranda, 2010; Byerlee, 2000; Huffman and Just, 1999; Klerkx and Leeuwis, 2008; Sumberg, 2005).

According to the OECD (1996, p. 21), in the knowledge-based economy the science systems –essentially public research– contributes to three key functions: i) knowledge production: developing and providing new knowledge; ii) knowledge transmission: educating and developing human resources; and iii) knowledge transfer: disseminating knowledge and providing inputs to problem solving. In this paper we claim that knowledge production and particularly that knowledge of the best quality is at the hart of the process. As a consequence, science production must fulfill an additional requirement related to quality; not all science is useful for companies, but only that with certain standards. We next review the main background on topic with a particular focus on the food industry.

Literature on university spillovers stresses that knowledge from university is a relevant input for improving o creating firms' innovation. But spillovers are far from being automatic. Sometimes there is a *spillover problem*, arising from a mismatch between the geopolitical entity conducting research and the geopolitical entities in which benefits accrue (Alston, 2002). Some characteristics of university knowledge, such as nature, diversity, and quality, are significant factors in determining the strength of knowledge spillovers and engagement with industry (Feldman and Audretsch, 1999; Mansfield and Lee, 1996; Feldman and Desrochers, 2003, Bae and Koo, 2008; Perkmann et al., 2011). Focusing on quality, Pavitt (2001) summarize the US experience by writing that "*US firms mostly use university research that is performed in high quality research universities, published in quality academic journals, funded publicly and cited frequently by academics themselves*", which is also stressed by Dosi et al., (2006) arguing that *useful academic research is good academic research*. In Europe, there is no much research on the role of quality. One exception is the paper by Fritsch and Slavchev (2007), who suggest that the strength of a university's impact on the innovative performance of private-sector firms may differ considerably according to the quality of their research. Their analysis in a German context shows that it is both the amount and quality of the research done at universities that is important for their contribution to the innovation system.

This brief review shows that the benefits from university scientific knowledge are not straightforward; the immediate implication is that the scientific knowledge production should be related to the needs of the productive system. Furthermore, the production of science is not enough –even if it is quantitative large or it is tailor-made to the firms' specialization– when there is a poor quality in the science produced by universities.

2. Empirical framework

2.1 Quantifying the closeness between science and technology

As pointed out above, we claim that quality is important for generate closeness between science and technology. A rough way to measure how close science might be to technology depending on quality is through correlations between these two variables and at the same time taking into account the level of scientific quality. Using rolling correlation is useful for this purpose. This kind of coefficient is quite common in financial economics to study the stability of the stock market indexes, analyse economic cycles, etc., always looking at the trend as one of the key variables. For this paer we count on a cross sectional sample of regions. Rolling correlation over □ groups of regions is estimated to measure the relationship between science and technology according to:

$$\rho_r(S,T) = \frac{\frac{1}{\lambda_j - 1}\sum_{i=r}^{r+\lambda_j}(S_i - \bar{S})(T_i - \bar{T})}{\hat{\sigma}_S \hat{\sigma}_T} \qquad r=1,2,...,R-\lambda_j$$

S= number of scientific papers in the region
T= number of food patents in the region.

Obviously, the rolling correlation coefficients depends on the arrangement of the data, dispositions of data according to different criteria provide different coefficients. Consequently, if we classified the regions according to the level of quality and then we obtain the rolling correlation coefficients between science and technology, we could conclude that this relationship rises if the rolling correlations increase, otherwise the closeness between science and technology would be independent of the level of quality.

3.2 Model explaining the closeness between regional science and technology

The basic model for identifying the factors affecting the quality of scientific research in the field of FS&T in European regions relates an indicator of quality to two explanatory variables of demand and supply side:

$$Q_{rt} = f(S_{rt-2}, D_{rt-2}, R_{rt-2}) + n_r + e_{rt} \quad \text{r=1,2, ..., R}$$

The subscripts r and t refer respectively to region r and time t. Q is the dependent variable which represents the average quality of the university science produced in the region; S is a set of factors capturing the characteristics of the universities which provide the supply of science in the region. D includes the characteristics from the demand side (firms). R captures the effects of the regional scientific policy. *v* is the unobserved heterogeneity at regional level and □ is the idiosyncratic error.

We next describe the measurement of our variables.

Dependent variable. Several quantitative indicators have been put forward in the literature to measure the quality of science. The most widely used is citations. It is quite common in contemporary research evaluation to use citation-based indicators at several levels to measure quality aspects of research (Moed, 2005). Smoch (2008) refer to several studies in which citation analyses are positively related to the results of peer review evaluations, showing the relationship between citations and standards of quality. Another similar indicator is the impact factor (the frequency with which the journal's articles are cited in the scientific literature, which is correlated with citations (Leimu and Koricheva, 2005). The use of impact factor as an index of journal quality relies on the theory that citation frequency accurately measures a journal's importance to its end users (Somnath, 2003). Some of the well known criticisms about both indicators (see for example,...), have been overcome in this paper because we use them for an individual discipline and using a particular number of journals in that discipline.

Independent variables:

Supply side. For capturing the characteristics of the supply side of science (universities), we include two variables: TPUB and FPUB/TPUB.

- TPUB: total number of scientific papers published by universities located in the region (in logs). We measure the scientific production of science at regional or national scale as the count of scientific papers published by academics in universities located in the region. Some papers have followed this procedure to determine the scientific capabilities of countries and regions and relate them to other variables (e.g. Adams 2005, Crespy and Geuna, 2008, Acosta et al., 2013). However, the simple aggregation of papers from different disciplines suggests that the results would be somewhat misleading because the different regional or country scientific specialization in particular fields. Alternatives measures such as the relative levels of investment in different disciplines or using research workers separated by disciplines are possibly alternatives, but difficult to put into practice because a lack of data (Abramo and D'Angelo, 2007). In this paper we avoid the problem of aggregation by taking only those papers in the field of Food Science and Technology (FS&T), one of the categories included in the Science Citation Index Expanded (SCI). The fact that the journals in FS&T are included in the SCI also guarantees that the papers have passed some standards of quality.

- (FPUB/TPUB). This variable captures the role of regional specialization. We obtain a simple measure consisting in the proportion of the number of scientific papers in FS&T in the total production of science in the region.

Demand side. The demand side for quality of science is captured with the variable PAT, which is the number of firm patents in the sector of food chemical and food machinery in each region. Patent data have been used extensively in economic geography, business economics, and macro-economics as indicators of the innovativeness of firms, industries, and regions (see surveys by Barsberg, 1987; Griliches, 1990). Patents cover virtually every field of technology useful for the analysis of the diffusion of key Technologies; patent data offer a World-wide geographical coverage; and it is possible to obtain a detailed classification schemes (Debackere, 2002). There are also well-known drawbacks as the different propensities to patent between sectors, problems that does not exist in our case as we analyse only one sector (food). Nevertheless, it should be borne in mind that patenting is not that frequent in the food sector, because of the high costs involved and because most innovations do not rely solely on new technologies (Hertzfeld et al., 2006, Wijnands et al., 2007). Additionally, the regional GDP per capita in PPS has been included to control for the level of wealth in the region.

Regional scientific policy. The variable HERDGDP (university expenditure on R&D-HERD as a percentage of GDP) is a proxy for the regional scientific policy . Financing university research is the basic instrument to spur science production in european universities and its quality. This variable also represent the attitude of regional governments to promote spillovers, as they usually seek not only encourage the supply of science, but to improve the channels of transmision from science to technology.

The empirical specification of the model is:

$$Q_{rt} = b_0 + b_1 \ln(TPUB)_{rt-2}\, b_2(FPUB/TPUB)_{rt-2} + b_3 \ln(PAT)_{rt-2} + b_4 \ln(GDPpc)_{rt-2}$$
$$+ b_5(HERDGDP)_{rt-2} + u_r + e_{rt}$$

3. Data

The data set used in this study for analysing the scientific regional profile consists of a set of 13,351 university research articles published in scientific journals indexed by the Science Citation Index Expanded (SCI) in the field of Food Science and Technology (FS&T). The period covered the years 1998–2004. SCI is part of Web of Science (WoS), which is a bibliographical database produced by Thomson Reuters. The main advantage of WoS is that it provides a complete list of all authors and their affiliations. There are also some well-known limitations of this database. For example, it does not include all journals, and the WoS journal list is strongly biased towards journals published in English (for details, see Bordons et al., 2002; van Raan, 2005; Weingart, 2005). The procedure to build our database followed these steps:

1. Data on academic publications containing at least one author affiliated with a university from an EU-15 country for 1998–2004 were retrieved from the SCI. It is worth noting that the lack of normalization in the way in which academic institutions are named hinders the finding of academic publications. For this reason, we included

several search terms to help identify higher education institutions in both English and other languages.

2. The second step involved regionalization at the NUTS II level of aggregation of the academic publications obtained in Step 1 (213 regions). We first identified the NUTS II associated with each university using the list provided by the members of the European Indicators, Cyberspace and the Science-Technology-Economy System (EICSTES). For those universities not included in the EICSTES list, we searched for the address on each university's website and matched them with the relevant region. Then, all publications were grouped by regions.

3. In the case of publications involving multiple regions, full counts were applied to all regions involved (i.e. crediting one publication to each region). As a result, in this step we obtained ... publications. In this step, it is important to note the concern argued by Hoekman et al. (2009) with respect to multiple affiliations. In most of the cases co-ocurrence of multiple regions in a publication involved different researchers. But it may also occur that a single researcher has multiple affiliations (e.g. if he/she works for two or more universities) and then reports more than one addresses in the publication. In these cases, the full-count method as also applied, crediting one publication to each listed region.

The main objective of the paper focuses on the scientific base knowledge in F&ST, at regional level, but in order to analyse the relationship with the regional distribution of private technology in the food industry, we have retrieved all available patent data in chemical food and food machinery from PATSTAT for the same period 1998-2004. This search resulted in 3,741 patents in sector 14; 3,737 in sector 25; and, 364 patents which covered both sectors. As in the case of scientific papers, we have regionalized the sum the sum of these three groups of patents.

4. Results

This section presents the three key issues in the paper. Firstly we map both the regional distribution of scientific papers and its quality. Secondly we obtain some relationships between science and technology using rolling correlations. Finally, we present the results of the model explaining the factor affecting the quality of regional science in FS&T.

4.1 Scientific knowledge base in food industry. Regional distribution and quality

We are interested in understanding the differences between patterns of regional of scientific knowledge sourcing activities pursued by food industry. To present a whole picture about the scientific knowledge base in F&ST we have mapped the regional distribution of scientific publications in Figures 1 and 2, while the Figure 3 present an index of quality of regional science.

Figure 1. Number of Scientific papers in FS&T 1998-2004

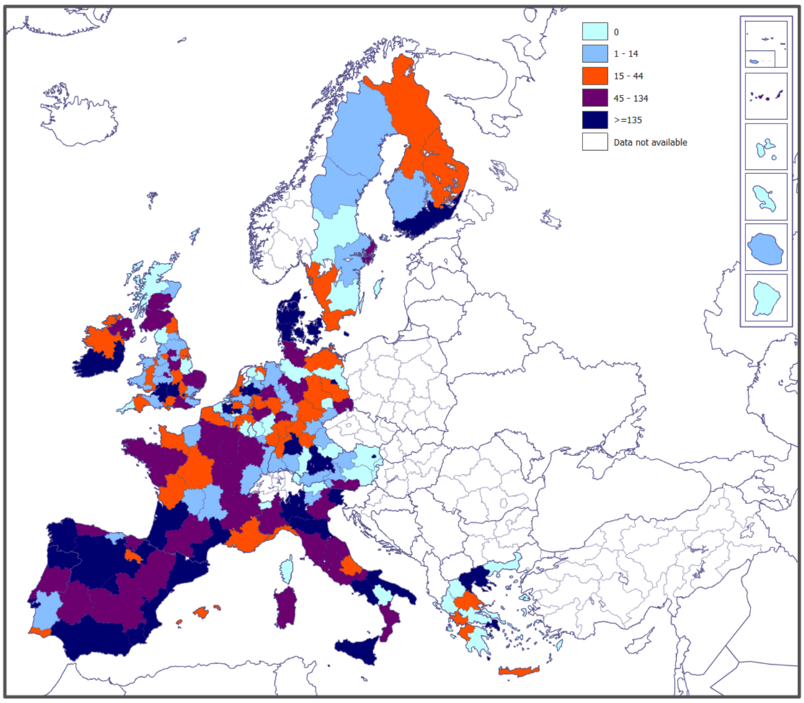


Figure 2. Number of Scientific papers (FS&T) per thousand inhabitants 1998-2004

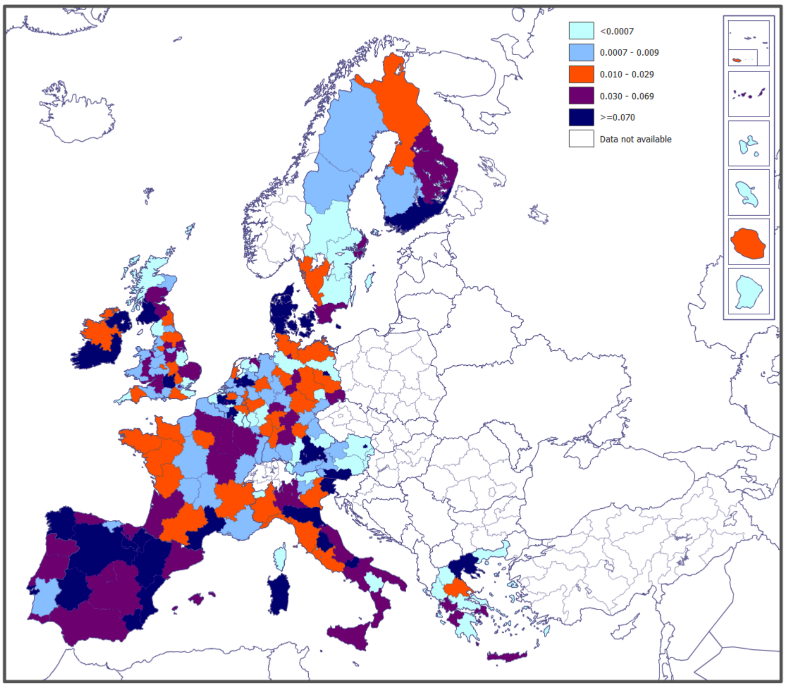
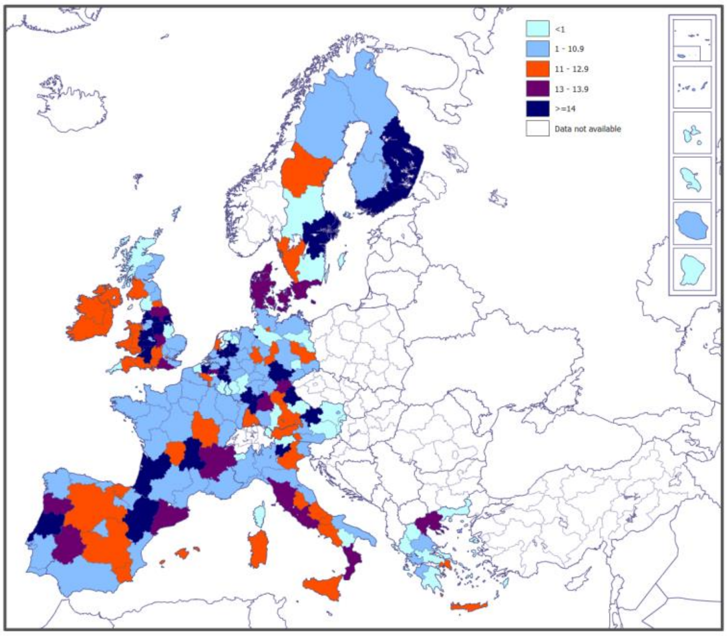


Figure 3. Average citations per paper in FS&T) 1998-2004



4.2 An approximation to closeness between regional production of science and regional production of technology

As we argued above, the success for the absorption of scientific knowledge in the same region where it was produced depends not only on the presence of a science knowledge base, but also on the quality of that knowledge. Then a positive correlation between the scientific production by universities and the technological capacity of the firms in the region is expected for regions in which there is a high quality of FS&T. To analyse this fact we have applied rolling correlation with a window of 50 observations after ordering the observations according to the level of quality. Figures 4 and 5 shows significant coefficients for a value of citations per paper greater than 11,6 and an impact factor of 1,24, respectively, while using other criterion as the simple arrangement by the number of papers does not lead to any significant relationship.

Figure 4. Rolling correlation between number of scientific papers and patents (per inhabitant). Data ordered from less to greater quality (citations)

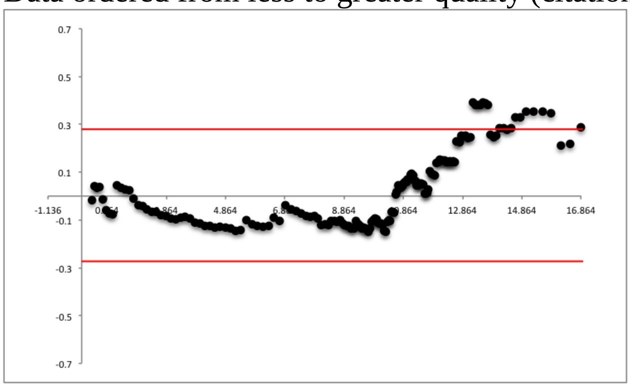


Figure 5. Rolling correllation between number of scientific papers and patents (per inhabitant). Data ordered from less to greater quality (Impact factor)

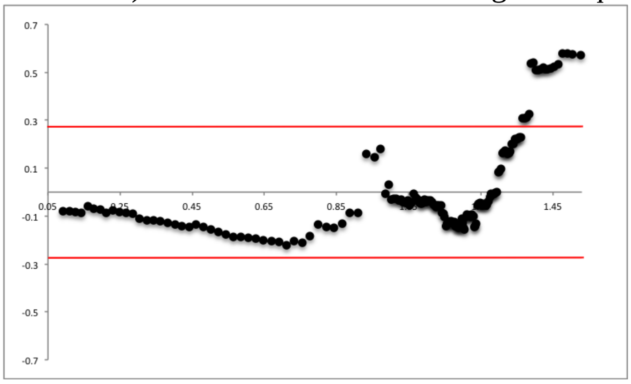
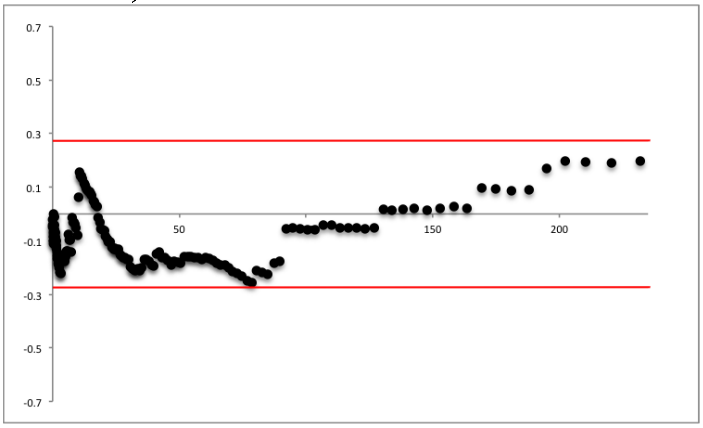


Figure 6. Figure 5. Rolling correlation between number of scientific papers and patents (per inhabitant). Data ordered from fewer to more scientific papers



4.3 Factors explaining the regional quality of science in the field of FS&T

Table 1. Descriptive statistics

Variable	Obs	Mean	Std. Dev	Min	Max
Q (Impact Factor)	495	0,9988	0,6032	0	2,647
Q (Citations)	495	8,8777	8,0725	0	78
HERDGDP	495	0,3522	0,2204	0	1,39
ln(TPUB)	495	5,7094	2,4747	-2,3026	8,73
FPUB/TPUB	495	0,0153	0,0207	0	0,159
ln(PAT)	495	-0,5960	1,9195	-2,3026	4,174
ln(GDPpc)	495	20280,2	5806,8	10200	61100

Table 2. Correlations n=495 (*)

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Q (Impact Factor)	1						
(2) Q (Citations)	0,574	1					
(3) HERDGDP	0,287	0,209	1				
(4) ln(TPUB)	0,582	0,397	0,467	1			
(5) FPUB/TPUB	0,265	0,173	-0,148	0,116	1		
(6) ln(PAT)	0,210	0,191	0,291	0,445	-0,146	1	
(7) ln(GDPpc)	0,146	0,049	0,211	0,275	-0,167	0,476	1

(*) Correlations have been calculated for the same number of observations as the estimated models.

Table 3

Linear regression with panel data. Estimation Results. Dependent Variable: Q (Quality of University papers) All observations								
	I. Q(Impact Factor)				II. Q(Citations per paper)			
	FE		RE		FE		RE	
cons	-0,9066		-0,0350		41,819	*	4,5977	*
HERDGDP	1,8448	**	0,2215	**	-0,6109		2,0110	*
ln(TPUB)	0,0092		0,1273	**	-2,1193		1,1369	**
FPUB/TPUB	-1,3389		4,9237	**	-16,4758		42,2152	**
ln(PAT)	0,0074		-0,0171		0,1984		0,3373	
ln(GDPpc)	0,0001	**	6,8e-06		-0,0001	**	-0,0002	
Number of obs	495		495		495		495	
Number of groups	153		153		153		153	
overall sign.	57,85	**	524,34	**	9,24	**	1903,54	**
Corr (ui_xb)	-0,682		0		-0,880		0	
F all Ui=0								
R within	0,095		0,004		0,068		0,006	
R between	0,134		0,590		0,171		0,335	
R overall	0,082		0,381		0,075		0,180	
sigma_u	0,673		0,243		14,007		3,841	
sigma_e	0,400		0,400		6,141		6,141	
rho	0,739		0,269		0,839		0,281	
Hausman fe vs re	23,02	**			5,93			

Notes:
- **, * denote that the coefficients are statistically different from zero at the 1% and 5% levels, respectively.

In order to analyse how robust our results are, we have estimated the same models but changing both the number of observations and the way in which have constructed the dependent variables. Table 4 present the models but omitting regions without universities (in this case, the number of observations reduced to 470, which means moving from 153 regions to 147). Table 5 includes the models omitting not only regions without university but also those in which the number of scientific publications in FS&T is zero.

Table 4

Linear regression with panel data. Estimation Results. Dependent Variable: Q (Quality of University papers) All observaions but only Regions with university								
	I. Impact Factor				II. Citations per paper			
	FE		RE		FE		RE	
cons	-0,8770		-0,1648		43,0709	*	3,6232	
HERDGDP	1,8434	**	0,1827		-0,2125		1,7615	*
ln(TPUB)	0,0005		0,1515	**	-1,9572		1,3869	**
FPUB/TPUB	-1,3326		4,9446	**	-16,5125		41,9702	**
ln(PAT)	0,0074		-0,0199		0,1997		0,3233	
ln(GDPpc)	0,0001	**	6,2e-06		-0,0010	**	-0,0001	
Number of obs	470		470		470		470	
Number of groups	141		141		141		141	
overall sign.	58,02	**	411,51	**	9,26	**	361,49	**
Corr (ui_xb)	-0,736		0		-0,831		0	
F all Ui=0								
R within	0,096		0,003		0,070		0,008	
R between	0,068		0,465		0,062		0,231	
R overall	0,050		0,284		0,027		0,129	
sigma_u	0,690		0,255		11,840		4,124	
sigma_e	0,408		0,408		6,256		6,256	
rho	0,741		0,281		0,782		0,303	
Hausman fe vs re	23,46	**			5,74			

Notes:
- ***, **,* denote that the coefficients are statistically different from zero at the 1% , 5% and 10% levels, respectively.
- VIF suggests no signs of multicollinearity.

Table 5

Linear regression with panel data. Estimation Results. Dependent Variable: Q (Quality of University papers) Regions with university and values >0 for ln(TPUB) (without univ is the same)								
	I. Impact Factor				II. Citations per paper			
	FE		RE		FE		RE	
cons			-0,2961		32,4521		-0,2456	
HERDGDP	1,9475	**	0,2167		-15,7344		1,7776	
ln(TPUB)	-0,3064		0,1705	**	1,2167		1,7495	**
FPUB/TPUB	4,5011		7,7867	**	104,6601		39,4883	
ln(PAT)	0,0786		0,0104		0,4089		0,2380	
ln(GDPpc)	0,0001	*	1,9e-06		-0,0011	**	-0,0001	
Number of obs	244		244		244		244	
Number of groups	101		101		101		101	
overall sign.	1155,45	**	807,68	**	189,96	**	320,87	**
Corr (ui_xb)	-0,802		0		-0,781		0	
F all Ui=0								
R within	0,092		0,027		0,113		0,030	
R between	0,008		0,446		0,019		0,113	
R overall	0,000		0,251		0,001		0,060	
sigma_u	0,747		0,221		12,570		6,486	
sigma_e	0,388		0,388		5,939		5,939	
rho	0,787		0,245		0,818		0,544	
Hausman fe vs re	4,73				1,75			

Notes:
- ***, **, * denote that the coefficients are statistically different from zero at the 1%, 5% and 10% levels, respectively.
- VIF suggests no signs of multicollinearity.

Conclusions and discussion

This paper has analysed two relevant issues related to the scientific knowledge base in the field of FS&T. First we have called attention on the fact that science production is not enough for creating a strong scientific knowledge base. The generation of science in universities needs some standards of quality for being useful for firms. After presenting the distribution of science across European regions and its quality, our main results points to a rise of the correlation coefficients between the science produced in the region and the generation of technology in the same region when the quality of science increases. We found significant rolling correlation when the average impact factor for the region takes a value larger than 1,24 or the average number of citation per paper is greater than 11,6. This result suggests that improving quality of science is a key factor to spur a close science-technology relationship. Note, however that a lack of significant correlation between science and technology does not mean that a region with a lack of scientific base has not a strong food technology; there is a group of "smart regions" in which firms can have access to scientific knowledge developed in other regions. This is perfectly plausible if they have the absorptive capacity for the acquisition and assimilation of that knowledge (Azagra et al., 2013). The problem is for the "donor regions" which provide the scientific knowledge but without taking advantage of it. We confront a spillover problem (Alston, 2002). In this case, what we can call the regional version of the "European paradox" (Dosi et al.) is present; that is, a region might has developed the capacity for the creation of useful scientific knowledge, but others reap the benefits.

The second conclusion refers to the factors affecting the quality of the food science. Several panel data estimates suggest that funding, research tradition and specialization are the main factors affecting the quality of FS&T, while the demand for science from the same region where that science is produced does not play any role.

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