Innovation and sectoral linkages in the agri-food system in the Valencian Community

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Abstract

This paper aims to analyze the innovative effort of the agri-food system (AFS) in the Valencian Autonomous Community (VC), Spain, estimating the intensity of innovation in each subsector of the AFS. The analysis distinguishes between the direct and indirect (or induced) innovation intensities incorporated by the acquisition of inputs from other subsectors produced in the VC or in the rest of Spain. The methodology employed is based on the input-output framework combined with data of technological innovation in enterprises. This methodology provides the novelty of been applied to a region —the VC— and not to a country as it is usually done. The results show that the weight of intersectoral flows in the total innovation effort of the AFS is significant with marked differences between primary and food industry. In most activities, embodied knowledge in inputs purchased from Spain is greater than embodied knowledge of inputs produced inside the region.

Additional key words: embodied knowledge; food industry; input-output; intersectoral linkages; primary sector; Spain; Valencian region.

Resumen

Innovación y vínculos sectoriales en el sistema agroalimentario de la Comunidad Valenciana

Este artículo analiza el esfuerzo innovador del sistema agroalimentario de la Comunidad Autónoma de Valencia (CAV), España, estimando la intensidad de innovación de cada subsector del sistema. El análisis distingue la intensidad de innovación directa y la intensidad indirecta (o inducida) incorporada en los inputs adquiridos por el sistema agroalimentario, indicando si es originada dentro o fuera de la región. La metodología empleada se basa en la utilización del marco input-output combinado con datos de innovación tecnológica en las empresas. Esta metodología aporta la novedad de ser aplicada a nivel regional —en la CAV— y no a nivel nacional, como se ha realizado hasta ahora. Los resultados muestran que el peso de los flujos intersectoriales en la innovación total del sistema agroalimentario es apreciable y muestra diferencias importantes entre la agricultura y la industria alimentaria. En casi todos los casos el conocimiento incorporado en insumos originados fuera de la región supera a los producidos dentro de la región.

Palabras clave adicionales: conocimiento incorporado; España; industria alimentaria; input-output; Región Valenciana, sector primario; vínculos inter sectoriales.

Introduction

This paper deals with flows of innovation among the agri-food system in a region and other sectors and territories[1]. The premise is that agri-food firms, in both the primary sector and the food industry, generate an effort in innovation that can be approximated in a direct way through the spending in innovation per unit of

[1] A preliminary and shorter summary of this research has been presented in the "International Conference on Food Innovation, 25 – 29 October 2010".

production (or value-added). But, in the context of "open innovation" (Chesbrough, 2003), a business activity also generates an indirect effort in innovation that appears incorporated into the products acquired from firms of other sectors or other territories. Thus, firms in the agri-food system may not show an innovative behaviour on their own but could be adopters of innovation through the acquisition of innovation intensive products. This is the hypothesis considered for the agri-food system in the Valencian Autonomous Community, Spain (here in after VC), considering both agricultural and food industry activities.

The literature classifies the agri-food system as a low Research and Technological Development (R&D) intensity sector (Connor & Schiek, 1997), which has also proven to be true in the case of Spain (Garcia & Briz, 2000). However it seems that, according to Lopez *et al*. (2003), the sector conducts as a "free user" adopting innovation generated in other sectors. Some studies dealing with the Spanish agriculture pointed to similar results highlighting the increasing dependence on imported technology (Rivas & Herruzo, 2003).

The data from the Survey on Technological Innovation in Enterprises (INE, several years)[2], despite its limitations, indicate low intensity of direct innovation both in the primary sector (sectors 01 to 05, International Standard Industrial Classification of all economic activities Rev. 3 —ISIC—) and the food industry (sectors 15 and 16, ISIC) in relation to other sectors. At this point two questions arise regarding the generation of technology in the agri-food, a sector that is supposed to be strategic due to its functions of food supply and occupation of territory.

The first question is whether the low direct intensity of innovation that is shown in the statistics, that will be discussed later, corresponds as well to a low indirect intensity of innovation in the relationships of agri-food with other sectors. Empirical evidence suggests that inputs from other sectors could represent the main source of R&D incorporation in the agri-food system like other traditional sectors (Hauknes & Knell, 2009). As Garcia-Martinez & Burns (1999) indicate, national and international suppliers of machinery and

equipment contribute considerably to the technological level of the Spanish food and beverages industry. Therefore, the interdependence between sectors can be an important source of knowledge. In this way, innovation in a sector could be performed by the use of improved inputs produced by other sectors. If this were the case the agri-food system would act as an "absorber" of innovations through the products acquired from sectors that perform direct innovation. Another point is that there may be differences between primary and agro-industrial sectors regarding the absorption of innovation that will be identified in the paper.

Assuming that technology incorporated in the agri-food through acquisition of products from other sectors could be significant, the second question would be where are those products made. That is, do products come from the same territory or are they imported from other regions or other countries? This question is especially relevant in agriculture and agri-food industry because they are considered closely linked to the territory. Therefore, the growth of these sectors is supposed to promote the development of the region in which they are located.

The purpose of this paper is to estimate how much innovation is generated in the agri-food system of the VC by direct innovation intensity and how much is due to indirect innovation intensity that in turn may come from the same region or from different ones.

The input-output framework has traditionally been used to measure knowledge flows among sectors. Former works of Terleckyj (1975) and Scherer (1982) combined macroeconomic data and data from R&D surveys. More recently Papaconstantinou *et al.* (1998) developed a method to estimate inter-sectoral technological flows that has been applied to OECD countries (Knell, 2008; Hauknes & Knell, 2009) and also to Spain (Camacho & Rodriguez, 2005). However, papers quoted are quite limited regarding the role of the agri-food in the generation and use of knowledge and on the effects of indirect innovation in sub national areas. This has led us to address this study to measure direct and indirect innovation in the agri-food system of the VC.

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[2] INE is the National Statistical Service of Spain.

Abbreviations used: ANBERD (Analytical Business Enterprise Research and Development Database); EU (European Union); INE (Instituto Nacional de Estadística); IVE (Instituto Valenciano de Estadísticas); R&D (Research and Technological Development); VC (Valencian Autonomous Community).

Methodology

The method is based on the open model of Leontief that allows the estimation of input-output multipliers matrix (Leontief, 1936, 1937). The multipliers measure the direct and indirect effects on the production system resulting from a change in a unit of final demand. The applications of this approach to the Spanish agri-food system are abundant (Enciso & Sabaté, 1995; López, 1995; Titos *et al.*, 1996).

At a regional level multipliers of Leontief's inverse matrix have been used to analyze productive impacts of exogenous changes in demand for agri-food products (De la Grana & Azaceta, 1990; Pérez y Pérez & Feijoo, 1993; Artis *et al.*, 1994; Iraizoz & Rapún, 2001). Other authors (García Álvarez-Coque & Enguídanos, 1999) have analyzed the inter-sectoral relationships of the agri-food sector and subsectors in the VC. And finally, in the field of innovation, Camacho & Rodríguez (2005) estimated indirect technological efforts induced in the productive sectors of the Spanish economy from a national approach, not a regional one as it is proposed in this paper.

The approach used in this paper is based on the methodology proposed by Hauknes & Knell (2009) that is also focused in a national level. They conducted a study comparing countries that has been adapted in this paper to analyze inter-sectoral linkages within a region and the relations between the region and the rest of Spain. The paper quoted combines the input-output framework with the Analytical Business Enterprise Research and Development Database (ANBERD) and it collects data on R&D intensity for eight industry groups although agriculture is not included among them. In this research regional and national statistics on innovation, focusing on agri-food sector, have been used.

The Leontief model is based on the equilibrium equation for the production system:

$$x = Ax + y \qquad [1]$$

where X is the output vector, A is the regional matrix of technical coefficients and y is the final demand vector. Assuming there is the inverse matrix (I-A), the system is resolved by the following expression:

$$x = (1 - A)^{-1} y \equiv By \qquad [2]$$

where B is the Leontief inverse matrix. The element of the B matrix indicates the direct and indirect effects on

the production sector i when final demand of sector j is increased by one unit ($i, j = 1, ... , N$, with N sectors).

Total innovation in sector j would include its own expenditure on innovation activities as well as the expenditure in the acquisition of innovation embodied in inputs from other sectors in the same region or in the rest of Spain. Then, the direct innovation intensity for sector i at a regional level (r_i) is defined as the direct expenditure on innovative activities (R_i) per unit of output (X_i):

$$r_i = R_i / X_i \qquad [3]$$

Multiplying the direct innovation intensities of sectors i by the elements (b_{ij}) of the matrix B, matrix T is obtained. Elements of matrix T (t_{ij}) indicate the total regional innovation incorporated per unit of final demand of the sector j:

$$T = \hat{r}B \qquad [4]$$

where $\hat{r}$ is a diagonal matrix whose elements are the direct innovation intensities (r_i). However, matrix T presents a problem of double accounting when measuring the intensity of innovation by unit of production and not by unit of final demand. In order to correct this problem, according to Hauknes & Knell (2009), a modified matrix B called B* has been obtained by dividing the elements of each column by the element of the main diagonal and later on by eliminating the elements of the diagonal to avoid double accounting of the direct effect of its own innovation intensity:

$$T^r = \hat{r}B^* \qquad [5]$$

In this way matrix (T^r), whose elements (t_j^r) measure the innovation intensity induced regionally in sector j in terms of production, has been obtained. Then, innovation intensity incorporated in inputs of sector j in the regional level is:

$$t_j^r = \sum_{i=1, i \neq j}^{N} \left(r_i \frac{b_{ij}}{b_{jj}} \right) \qquad [6]$$

In this way, total innovation intensity of sector j (r_j^r) in the regional level could be defined as the sum of the own innovation intensity of the sector j (r_j) plus the innovation intensity embodied in the products and services acquired inside the region (t_j^r), as follows:

$$r_j^r = r_j + t_j^r \qquad [7]$$

Moving forward, the estimation of the direct and indirect innovation intensities generated within a region can be accurate by adding the indirect innovation intensity found in the products imported from the rest of Spain. In order to consider them it is necessary to know the innovation intensities of each sector and territory where the products come from. Note that this paper takes into account the products coming from the rest of Spain considering only their direct innovation and not including the indirect innovation induced by them.

Then indirect innovation due to products imported from Spain is:

$$t_j^E = \sum_{i=1}^N r_i^E m_{ij}^E \qquad [8]$$

where (t_j^E) is the innovation intensity of sector j due to the inputs imported from the rest of Spain, (r_i^E) is the direct innovation intensity of sector i at the Spanish level and (m_{ij}^E) are the elements of matrix M^E. Each element of this matrix is the coefficient of imports that sector j of the VC acquires from Spain, expressed in units of output of sector j.

Therefore, the total innovation intensity of sector j (r_j^t) is the sum of the direct innovation intensity (r_j), plus the indirect innovation intensity induced at regional level (t_j^r), plus the indirect innovation intensity incorporated by its imports from the rest of Spain (t_j^E).

$$r_j^t = r_j + t_j^r + t_j^E \qquad [9]$$

The relationship between the total innovation intensity and the direct innovation intensity is indicated by the technological multiplier. A value of the multiplier around 2 implies that the total innovation intensity is made up fifty-fifty of direct and indirect innovation intensity. If the multiplier is greater than 2 it means that the indirect innovation is larger than the direct innovation. In this way the technological multiplier reflects the productive structures of the region or the sectors analyzed indicating how technical knowledge is created and used. If a sector (or the region) has a low multiplier it implies that the sector (or the region) generates knowledge. In the same way a high multiplier indicates that the sector (or the region) uses knowledge generate by other sectors or regions.

It is worth to indicate that, in this analysis, technological effort is considered in terms of innovation intensity, that is to say, total direct expenditure on in-

novation activities over the turnover of the sector. Apart from the direct technological effort of the sectors in the VC the estimation also considers the indirect technological effort induced by intermediate products purchased both in the region and in the rest of Spain. It has to be noted that other sources of innovation such as imports from outside Spain or knowledge embedded in capital goods, either regional or imported, have not been considered in the present exercise. Another limitation would be the innovation performed by entities such as cooperatives, professional associations, foundations, etc, that are not reflected in the sources of information used. In this way the paper offers an exploratory analysis of the capacity of the agri-food system in the VC to generate innovation through sectoral linkages related to transactions of intermediate products. Future work is needed in order to overcome these limitations.

Regarding the data used in the analysis, two main sources of information have been used: i) the input-output matrix of the VC. The latest one available is from 2000, updated in May 2008; ii) the Survey on Technological Innovation in Enterprises of 2006, which is the first year that the survey takes into account agriculture. The data for the VC comes from IVE (*Instituto Valenciano de Estadística*, Valencian Statistics Service) and the data for Spain comes from INE (*Instituto Nacional de Estadística*, Spanish Statistical Office).

The structure of innovation intensity data for the VC published by IVE is divided into 15 groups of economic activities. In order to be comparable with data for Spain (54 business activities), the table of the equivalence shown in Supplementary Table 1 (pdf) was elaborated. The analysis assumes that the innovation intensity average for a group can be assigned to each of the subsectors forming the group. This assumption implies a constraint on the accuracy of the innovation intensity considered for the subsectors but there are not easy alternatives given the information available.

The induced innovation intensity from outside the region has been estimated trough the intermediate consumption matrix of products imported from Spain. This matrix has been calculated using the input-output framework of VC (total symmetric matrix minus interior symmetric matrix). Thus it is possible to estimate, for each sector j, the proportion of total imports coming from the rest of Spain. This ratio, applied to intermediate consumption products produced in each sector i and bought by each sector j, makes it possible to estimate

Table 1. Innovation intensities for agri-food system and other sectors (% of value added) in the Valencian Autonomous Community (VC)

	Agri-food system	Other sectors	Total VC
R	1.53	1.06	1.08
t^r	0.46	0.29	0.30
t^E	0.76	0.72	0.72
r^{total}	2.75	2.07	2.11
Technological multiplier	1.79	1.96	1.94

Source: Drawn from the Input-Output frame of the VC (IVE, 2008) and Innovation Survey (IVE, INE).

the import matrix of sector *j* in Valencia (imports from the rest of Spain as has been indicated). Then, imports per unit of output of sector *j* are obtained dividing the elements of each row of the matrix by the total production of every sector *j*.

Results and discussion

Results are presented in three sections from more to less aggregate. The first one refers to the agri-food system as a whole; the second one focuses on the two main subsectors: primary sector (including agriculture, livestock, fisheries and forestry) and food industry; and the third one decompose main sectors in economic branches.

According to the results, total innovation intensity of the agri-food sector is greater than the average of all the sectors of the VC. Both components, direct and indirect innovation intensities, are greater in the agri-food sector than in the average of other sectors as it is shown in Table 1. These results would refute the generally accepted idea that the agri-food sector is scarcely innovative (see for example Connor & Schiek, 1997; Garcia & Briz, 2000). Besides, it is worth to highlight the capacity of agri-food sector of the VC to induce innovation in the own region compared to the whole Valencian economy. From this perspective, the agri-food sector would be strategic for the territory as it induces more innovation in the region than the rest of the sectors.

In an attempt to deeper analyze the agri-food system it has been broken down into primary sector on the one hand and food industry on the other. The rest of the sectors of the VC have been grouped according to the technological classification used by Hauknes & Knell

(2009)[3] which identifies the following groups of industries: Energy, Materials, Traditional, Scale-intensive, Science-based, Specialized-suppliers, and Services (the industries included in each group are shown in the Supplementary Table 2 (pdf)). Results are shown in Table 2.

Deeper analysis on subsectors forming the agri-food system show no positive results for the primary sector. This subsector (including agriculture, livestock, forestry and fishing) shows the lowest innovation intensity, even smaller than services. These results follow the same trend found in other studies (Connor & Schiek, 1997; Garcia & Briz, 2000; Garcia-Martinez *et al.*, 2010). Its composition is made fifty-fifty by direct and indirect innovation and follows the same pattern as the average in the region. The indirect innovation induced by imports from the rest of Spain is bigger than indirect innovation induced in the region through inter-sectoral linkages.

However, the food industry shows a value of innovation intensity (5.58%) bigger than other sectors that *a priori* are expected to be higher (for instance Materials is 3.8%, and other traditional sectors is 3.35%). Moreover, food processing stands out as the sector that induces more innovation inside the region (0.95%), even more than science based sectors (Table 2 and Figure 1) These results may question the classification of food processing as a traditional sector (Hauknes & Knell, 2009; Eurostat, 2011). The innovation intensities obtained are close to those of other innovation-intensive sectors such as scale-intensive sectors and specialized suppliers. In this sense Robinson *et al.* (2003) consider food industry as a scale-intensive industry in the taxonomy of innovation they developed (Supplementary Table 2 (pdf) and Figure 1).

The international study of economic sectors made by Knell (2008) was compared with the results obtained

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[3] This classification is a modified version of technological taxonomy developed by Pavitt (1984).

Table 2. Innovation intensities of sectors (% of value added) in the Valencian Autonomous Community and total value added

	r	t^r	t^E	r^{total}	% value added	Multiplier
Agriculture	0.47	0.14	0.31	0.92	3.3	1.97
Food industry	3.18	0.95	1.45	5.58	2.1	1.75
Other traditional sectors	1.38	0.55	1.42	3.35	17.2	2.42
Energy	0.54	0.20	1.04	1.78	1.4	3.29
Materials	2.61	0.63	0.57	3.80	5.7	1.46
Scale intensives	4.56	0.44	2.92	7.92	4.5	1.74
Specialized suppliers	4.58	0.58	0.80	5.96	1.6	1.30
Science based	14.69	0.94	4.99	20.62	0.2	1.40
Services	0.47	0.18	0.37	1.01	64.1	2.20
Average	1.08	0.30	0.72	2.11	100	1.94

Source: Drawn from the Input-Output frame of the VC (IVE, 2008) and Innovation Survey (IVE, INE).

here for the VC (Table 3). Knell considered R&D intensity as a component of the innovation intensity. In order to solve this inconvenient the R&D intensity for the VC was estimated. Another difference between Knell's and our approach is the scope of the territory considered in the study: countries in Knell's paper and regions in this one. As countries are larger economies they integrate more inter-sectoral linkages and, consequently, countries would induce more innovation intensity than regions. Despite these limitations the comparison makes it possible to place Valencia food

industry in an international context in order to appreciate its dimension.

From these data it can be inferred that: i) direct R&D intensity and total R&D intensity of food industry are higher in the VC than in Italy, Portugal or Greece but lower than in Spain; ii) induced R&D intensity in the territory is higher in Spain than in the VC, to certain extent because Spain is a bigger economy and therefore has more inter-sectoral linkages, as it has been mentioned; iii) total R&D intensity of food industry in the VC is similar to Italy, lower than Spain, The Nether-
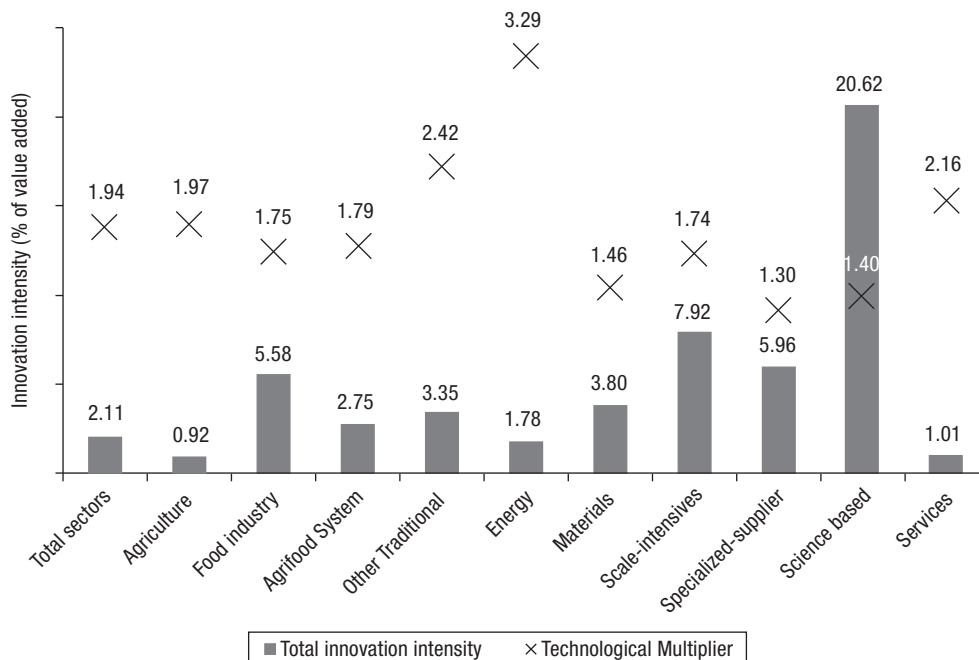

Figure 1. Innovation intensities by industry in the Valencian Autonomous Community and the technological multipliers.

Table 3. Food industry R&D intensity in the Valencian Autonomous Community (VC) and some European countries (% of value added)

	r	t^r	r^{total}	Size value added food industry in 2000 (VC = 100)
VC	0.46	0.34	0.79	100
Spain	0.70	0.73	1.43	488
Netherlands	2.44	1.03	3.47	370
France	1.28	1.72	3.00	1,070
Italy	0.42	0.34	0.76	732
Ireland	1.22	0.23	1.45	117
Portugal	0.08	0.24	0.32	111
Greece	0.34	0.26	0.60	95

Source: VC input-output matrix (IVE, 2008); Innovation survey (IVE, 2002; Knell, 2008).

lands, Ireland or France and higher than Greece and Portugal.

There are substantial differences between the primary sector and the food industry. First of all, innovation intensity is around six times higher in the food industry than in the primary sector (see Table 2 and Figures 1 and 4). Lower skill levels in rural areas may be a factor limiting innovation. In most OECD countries the performance of students in the International Student Assessment-PISA (OECD, 2006) shows a significant gap between urban and rural students. Popula-

tions in rural areas tend to be older and less well educated than in metropolitan regions. Rural regions rely on traditional skills with a weak position in skills needed for modern services and the use of advanced technologies (OECD, 2009).

Focusing on agriculture, citrus —the main subsector in terms of value added— has quite low innovation intensity, around 0.8% (Table 4). Besides, induced innovation in the region is very limited, around three times lower than induced innovation in Spain. Livestock has the highest total innovation intensity in the
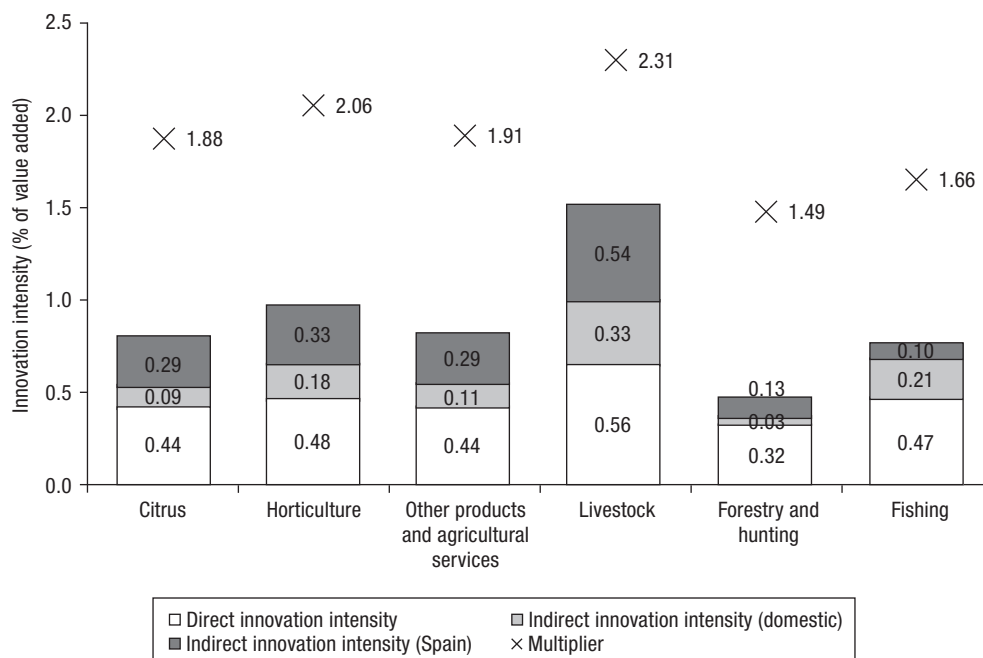

Figure 2. Innovation intensities in the primary sector (agriculture, livestock, forestry and fishing).

Table 4. Innovation intensities in the agrifood subsectors (% of value added), total value added (% of agrifood sector) and technological multiplier

	r	t^r	t^E	r^{total}	% Value added	Technological multiplier
Citrus	0.44	0.09	0.29	0.82	26	1.88
Horticulture	0.48	0.18	0.33	0.98	9	2.06
Other products and agricultural services	0.44	0.11	0.29	0.83	15	1.91
Livestock	0.66	0.33	0.54	1.52	7	2.31
Forestry and hunting	0.32	0.03	0.13	0.48	0	1.49
Fishing	0.47	0.21	0.10	0.77	4	1.66
Meat industry	4.04	1.36	1.38	6.78	5	1.68
Processing and preservation of fish, fruit and vegetables	3.47	1.12	1.52	6.10	3	1.76
Manufacture of dairy products	3.60	1.41	1.96	6.97	4	1.93
Manufacture of grain mill products	1.52	0.30	0.49	2.31	16	1.52
Manufacture of other food products[1]	9.68	3.05	5.83	18.55	3	1.92
Manufacture of beverages	3.60	1.08	1.66	6.35	7	1.76
Manufacture of tobacco products	1.60	0.31	0.62	2.54	1	1.58

Source: VC Input-Output matrix (IVE, 2008) and Innovation Survey (IVE, INE). [1] "Other products" has not been analyzed because is very heterogeneous and its ratio value added/production is so small that distorts the results.

primary sector (1.52%). These results are in line with other studies that characterize this sector as an innovation subsystem with the meat industry (Pitt & Nelle, 2008). The value of the multiplier, greater than 2, indicates that induced innovation is bigger than direct innovation. Horticulture follows the same pattern (Table 4 and Figure 2) with a lower innovation level in Spain as found in other studies (Garcia-Martinez *et al.*, 2010).

Regarding food industry, grain mill manufacture -the main subsector in terms of value added- has the lowest innovation intensity (2.31%). On the opposite side, the dairy industry shows the highest innovation intensity (6.97%) followed by meat industry (6.78%) (Table 3 and Figure 3).

The direct innovation intensity is higher than the induced innovation in most of the sub-sectors in the primary sector and the food industry. It implies that the technology multiplier is generally lower than 2, except for two sectors highly dependent on intermediate and imported inputs from outside: horticulture and livestock (Table 4). The induced innovation in the region measures the contribution of each sector to the innovation effort within the economy. The induced innovation at the national level (Spain) is found to be higher than induced innovation within the region for most subsectors, except fishing and meat industry. Livestock and dairy industry show the highest values for induced innovation in the primary sector and the food industry respectively (Table 4).

It is paradoxical that economic branches with significant share in the primary sector, such as citrus, horticulture and other agricultural activities (Figure 4) show relative low levels of innovation effort. This might be connected with several factors. One of them is the fact that there are some kinds of innovation that are not expressed in terms of innovation expenditure. Other one is the weak farm structures, based on small enterprises that limit innovation investment. Innovation, like critical grow factor in the agri-food system (Russo Spena & Colurcio, 2010) can be considered to certain extent as a public good and many farms are innovation takers rather than innovation enhancers. In this case, government action promoting innovation is more than justified.

Possible measure to improve the innovation performance of the agri-food system is the strengthening of interactions between agents in the system. Two kinds of interactions can be taken into account (Europe Innova, 2007). One is to promote innovation through enhanced cooperation and exchange between firms. In particular, interactions with knowledge-intensive sectors, given their importance in the generation and diffusion of innovations, can be strengthened (Mas Verdú *et al.*, 2011). In this empowerment of innovation networks, the innovation brokers may have a key role (Batterink *et al.*, 2010). The other is to enhance partnership between the business sector and public support services to R&D activities. Such kind of services play an es-
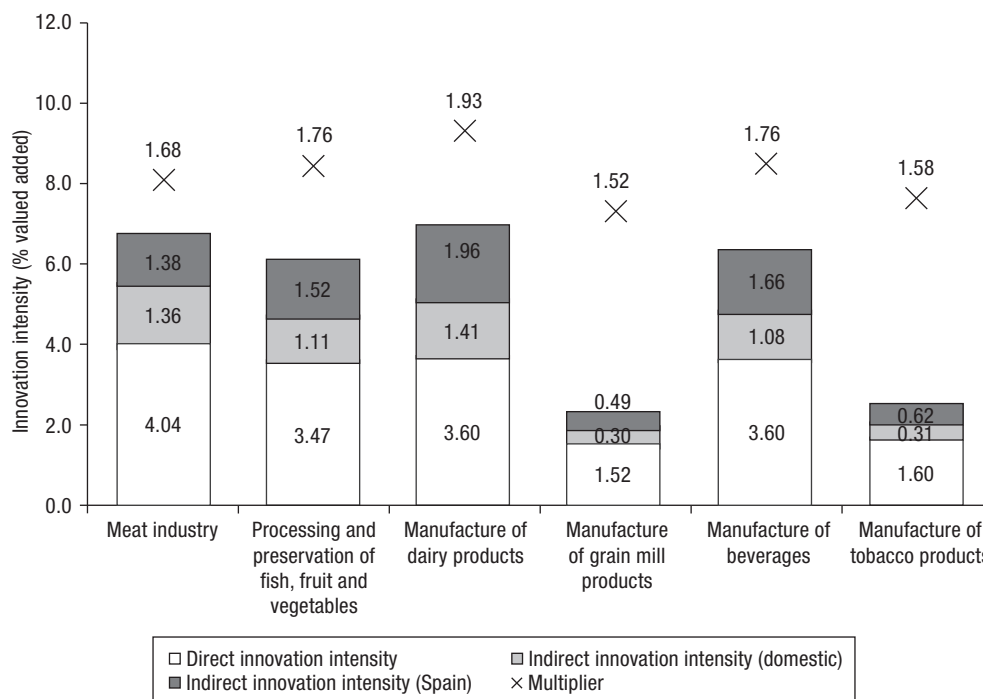
Figure 3. Innovation intensities in the food industry.

sential role in parts of the agro-food system still dominated by Small and Medium Enterprises, such as the primary sector and a large number of food processors.

As conclusions, the agri-food system has been considered strategic from a policy perspective because of its role in the provision of food and other functions as land use, environment protection and biodiversity conservation. This paper highlights its contribution to the generation of knowledge and innovation through intersectoral linkages established with other economic sectors.

The methodology used in this paper combines the input-output framework with innovation intensities data. The method, applied to the VC, makes it possible to distinguish between direct and induced innovation from a regional perspective. In turn, induced innovation is divided into innovation induced in the region and innovation induced in the rest of Spain. The contributions of this paper in regard to the pre-existing literature on the subject are: i) the estimation of inter-sectoral flows of innovation in the agri-food sector including both agriculture and agro-industry; ii) the estimation of inter-sectoral flows of innovation at the subnational level.

Both the primary sector and the food industry induce innovations through the acquisition of intermediate inputs produced in other sectors. Technological multipliers are found to be greater than 2 for horticulture and livestock. The food industry stands out for its innovation intensity higher than the one estimated for primary sector and also higher than most values calculated for traditional industries of the Valencian economy. The induced innovation by the food industry within the region is also remarkable. The innovation intensities for the Valencian food processing are estimated to be higher than those found in the literature for other Southern European countries.

Despite the limitations of the data bases used (input-output matrix and technological survey) the results are an attempt to approach the contribution of the agri-food system to the regional economy of innovation, through direct efforts or through intersectoral linkages. Particularly in agriculture, due to the great majority of micro, small and medium sized enterprises (SMEs), the primary sector reveal low levels of innovation efforts, which may justify government intervention promoting agricultural research and innovation. Innovation in the Valencian agri-food economy seems largely induced from other sectors in the region and in the rest of Spain.

Therefore this approximation on innovation in the agri-food system could be useful to guide public poli-
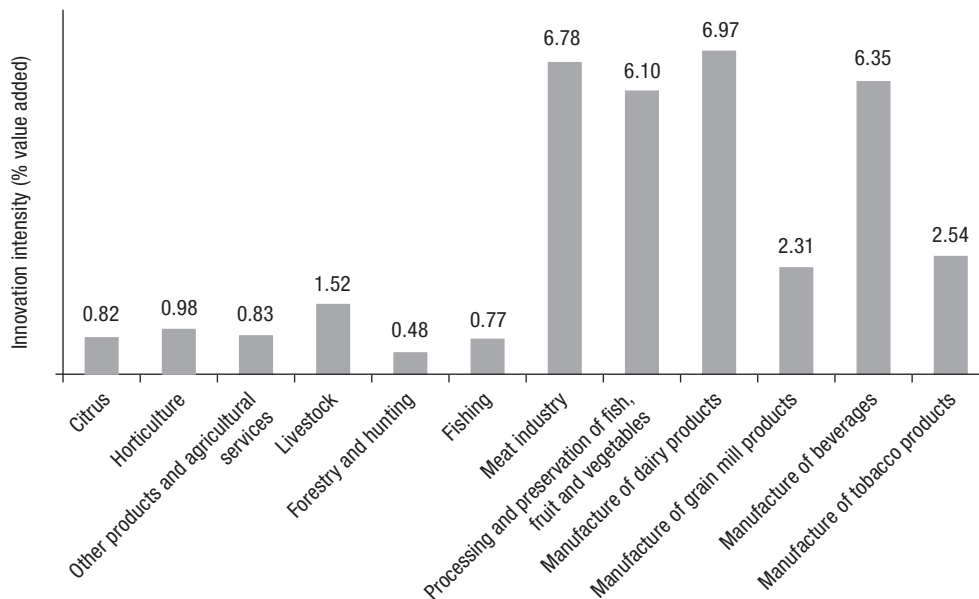
Figure 4. Total innovation intensities in the agri-food system.

cies targeted to promote innovation. It is essential that these actions converge with agricultural policy instruments in order to foster the EU growth and become a sustainable, smart and inclusive economy.

Acknowledgements

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