



Innovation in the functional foods industry in a peripheral region of the European Union: Andalusia (Spain)

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ARTICLE INFO

Article history:

Received 10 August 2008

Received in revised form 30 October 2009

Accepted 17 December 2009

Keywords:

Functional food
Innovation system
Public sector research
Research group
Spin-off companies

ABSTRACT

This paper presents the results of an analysis of the relationship between public sector research and industrial development in the functional foods sector in a peripheral region of the European Union: Andalusia (Spain). Results show that the innovation system and its component parts have made a qualitative and quantitative leap forward in the last decade, which means that the gap is diminishing compared to similar regions in the European Union, mainly due to a relatively intense effort from the public research sector. In order to take advantage of the potential of the Andalusian region, the public authorities will have to focus their efforts and funds on fostering relations between regional social players that lead to the creation of durable links; increasing the entrepreneurial spirit of university students/researchers; promoting and improving the quantity and quality of international excellence research groups; and stimulating the creation of scientific and technological parks where spin-off companies can contribute to increasing wealth and employment in the region.

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Introduction

The transfer of knowledge between researchers at universities and the private sector has been widely analysed in Research and Development literature (see Bate and Robert, 2002; Shapiro et al., 2007; Hazlett et al., 2008 among others). European Union, national and regional initiatives aim to foster cooperation between business and the academic world by bringing universities closer to business environments (Dowling and Helm, 2006; Grupe and Kusi, 2008). These include the various European frameworks, as well as specific networks such as EUREKA for market-oriented, industrial R&D. In Southern Europe, the ATYCA and PETRI projects are attempting to promote the transfer of scientific and technical knowledge from universities to the production, service and public sectors. In this context, the role of universities has changed dramatically with governments giving maximum priority to promoting links and cooperation between the academic world and industry (Bayona et al., 2004). Under this perspective, specific research into biotechnologies is receiving increasing attention in line with growing expectations for future industry development. More specifically, functional foods research is gaining importance as the interest in nutrition as a positive force for health grows within society at large (Niva and Mäkelä, 2007; Nordstrom and Bistrom, 2002). Functional food is

any fresh or processed food that is claimed to have a health-promoting and/or disease-preventing property beyond the basic nutritional function of supplying nutrients. These foods may help prevent disease, reduce the risk of developing disease, or enhance health. Most analyses of the determining factors enabling innovation in health sciences have focused on public and private innovation initiatives by macroeconomic geographical agents such as the European Union (EU), the United States (US) and Japan. Nevertheless, specific literature has pointed to an emerging interest in regional studies, as food industries adapt to significant regional differences in traditions, cultures, customs and practices (Rodríguez-Pose and Crescenzi, 2008).

This paper presents the results of an analysis of the relationship between public sector research and industrial development in the field of functional foods in a peripheral region of the European Union: Andalusia (Spain). In addition, specific aspects such as the effect that research at universities exerts on growth and the creation of industrial initiatives are analysed from the perspective of EU research policies for similar EU regions. These kinds of regions are typified by a growing food industry sector supported in part by a traditional agricultural sector that is well-rooted all over the region. In economic terms, according to an EU Report from 2005, the GDP per capita in Andalusia was 80.4% of the European Union average. The region will continue to receive support from EU structural funds until 2013, as it is still considered an EU Objective 1 Region.

In our research, we have tried to relate an increase in university scientific production with the introduction and development of a

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regional functional food industry. This has been done by studying how public investment actions in both research and productive systems generate value added synergies (Arias-Aranda, 2007) that highlight the benefits to be gained by both parties from cooperation and knowledge transfer (Greunz, 2005). Issues such as the impact of globalization and the effects of delocalization of research and production activities on regional innovation systems are also covered in this analysis. We have also assessed the efforts made in terms of the technology watch for new products and processes and the analysis of the scientific and productive environment, in order to identify the opportunities and hazards for regional development (Moreno et al., 2005).

The main findings of the analysis show that public regional investment in R&D encourages the private sector to invest on a local basis and also complements business-creation projects financed for the most part by regional funds. For the functional foods sector, public sector support for R&D combined with high-quality academic research has laid the foundations for attracting private resources and assets to establish a local and regional food industry based on the generation, transfer and exploitation of valuable knowledge (Parent and Riou, 2005). Nonetheless, the high degree of interdependency between the public and private innovation system is not exempt from risks produced by opposing interests, such as the fact that researchers' personal promotion activities may sometimes take priority over investigations interests of the private sector (Greunz, 2004).

Growth and importance of the functional foods industry in the global and regional contexts

Andalusia in the Spanish and European economic framework

Andalusia became an autonomous region in 1981. The Spanish state is made up of 17 such regions of which Andalusia ranks number 16 in GDP per head with a total of 17,251 euros in 2006. Since 1995 Andalusia has gradually converged with the European Union in economic terms and has reduced the gap with its most developed European partners by more than fifteen points. However, it is still included in the tertiary oriented cohesion cluster by the EU Committee of the Regions.

In general terms, the Andalusian industrial structure is based on small and medium-sized firms (almost 70% of the firms located in Andalusia have less than three employees). The rate of currently-operating companies per 100 inhabitants is less than 6.5 (the average for Spain is 7.1). However, over the period 2000–2004 there was a significant increase in the number of firms created, which rose at a rate of 20% a year. Even though initiatives to increase cooperation and set up innovation networks have been launched by both the public and the private sectors, general levels of cooperation are still far below EU averages (INE, 2007).

Venture capital initiatives have not become popular within the Andalusia region as an instrument for promoting the creation of companies in technological sectors. Most initiatives are financed through public support according to different programs offered by the regional government. In addition, in terms of spending, the Andalusian innovation system still performs below the Spanish average, as total R&D expenditure comes to only 0.69% of the region's GNP in comparison with 0.96 for Spain as a whole. The gap is even wider if we compare private R&D expenditure (as a percentage of GNP in 2004) for Andalusia (0.17) with that of Spain (0.50). In fact, in 2007, construction accounted for 14.88% of the gross added value of the whole region, while services, and in particular tourism represented a massive 68.79%. The figure for the

industrial sector fell from 20.11% in 1980 to 11.42 in 2007 (INE, 2008).

2.2. The functional foods industry

Functional foods are closely related to health maintenance and preventive medical care. Functional nutrition originated in Japan during the 1980s when the government financed a national research project on the implications of medical sciences for diet, in order to guarantee good health conditions for the older population. The US and EU soon became interested in the benefits that functional foods could provide for individuals with poor diets based on saturated fats and low vitamin and fibre intakes. The functional foods industry started focusing on the development of products that reduced the risks of cancer and coronary disease by reducing cholesterol levels. Innovative products with soy stanol esters that reduce cholesterol (*Take Control* by Lipton/Unilever and *Benecol* by McNeil/Johnson & Johnson) boosted interest in food industry research into the use of soy as a base for functional foods (Junta de Andalucía, 2007).

In Europe, research into functional foods focussed on intestinal health. *Probiotic Yogurt LC1* by Nestlé in 1994 and *Actimel* by Danone rapidly increased customer interest in this type of nutritional product. In response to the increasing demand for these products, the EU created the Functional Food Science in Europe (FUFOSE) in order to coordinate studies into the development of food products with beneficial effects on physiological body functions and disease risk reduction.

There are currently more than 200 functional food product types on sale in Spain. At the same time, the increasing interest shown by the food industry in the production of these kinds of products has led to the development of auxiliary services based on research into functional foods. Over 140 companies from more than 20 countries participated in the European Functional Food Network (FFNet) which was funded by the European Commission under the 6th Framework Programme. Andalusia had a total of 29 firms producing functional products in the 2007 census. Almost 49% of these companies are located in the province of Granada, while a further 13.7% are based in Córdoba and 10.3% in Seville.

Public funds on a regional basis are being invested to enlarge spin-off creation activities as private initiatives in this matter are still below EU averages. The Andalusian functional foods industry has followed a similar path to countries like Germany or France, where after initial drawbacks local industries soon experienced fast growth (Todt et al., 2007).

Methodology

The relationship between public policies based on investments in R&D resources and capabilities and the increase in patents produced by an increasing number of researchers in the functional food industry at a regional level have been widely analysed in economic literature (see among others Lehrer, 2007; Haaland and Kind, 2006; Coronado and Acosta, 2005; Moso and Olazarán, 2002). More specific studies have analysed this relationship in wider contexts (Pueyo and Sanso, 2005; Tassej, 2005) considering innovation as an endogenous variable that moderates the relationship between growth policies and technological change. These frameworks form the basis for this study. In the particular case of the functional food industry, we have identified two different forms of innovation: innovation involving interdependence between basic and applied research requiring leading edge scientists beyond the product launching stage, known as embryo innovations (Lehrer, 2007) and those which tend to follow a linear R&D model (Gibbons et al., 1994). These different forms of innovation build up

the framework within which the different variables can connect. In this study we have analysed the relationship between public policies on innovation and R&D results and technology transfers to the functional foods industry, all within the context of the Andalusia region of Spain.

The information we have drawn on in this study is based on public sources in the form of regional government studies; reports from nutrition research centres and industrial business surveys. Regional innovation policies for the functional foods sector are shaped by the relationships between these economic agents. By analysing complementarities and common efforts on product research goals, this study attempts to throw some light on the different measures and forces that have led to the development of the functional food sector in Andalusia. Public data from 29 firms in Andalusia, complemented with data from 27 firms from the sector operating in the rest of Spain and in other countries, was arranged to obtain information about sector growth figures (INE, 2007). In addition, data reports from 21 Andalusian research centres and universities with research lines on functional foods were used to evaluate scientific production in the nutrition and dietetics field in the region. The third and final source of information for this analysis were reports produced by the regional government on regional research and development policies for 2007, and sector-based studies for that year. Since 1997, there has been a very positive trend with an increase of 58% in the number of functional food firms established in Andalusia. 92% of these companies are concentrated in the provinces of Granada and Seville.

Relations between the regional and national government, research centres, universities and the functional foods sector were considered under a broad definition that included R&D projects financed by at least one economic agent and/or the EU 7th Research Framework Program. Scientific production was measured by the number of scientific publications in specialised academic journals on the different types of functional ingredients, and the national and international patents and other technological results. An intra-regional indicator (IR) was developed to establish comparisons between provinces within Andalusia in order to highlight internal differences. This indicator was constructed on the basis of recent studies of R&D cluster indicators and technology dispersion (Salazar et al., 2008; Mulas-Granados and Sanz, 2008). The IR indicator involves established functional food firms (F), Scientific Publications (SP), Research Groups (RG), Research Centres (RC) and Patents (P). All items were added and referred to a 0–100 scale where 100 was reached by the highest score produced by the addition of items over a percentile base using data from 2007 (INE, 2007).

Functional foods research and development in Andalusia

In the food manufacturing sector, fats and oils production achieves the best figures for added value in Andalusia (35.9% (INE, 2006) where 93% of food industry companies have less than 20 employees. Nonetheless, Andalusia is the second autonomous region in Spain after Catalonia in terms of income from sales of food products providing 14.7% of the overall Spanish total and 13.8 of the total employees in the food sector (Report *S.G. de Fomento Industrial e Innovación Report*, 2007) (Table 1). This position in the ranking reflects the research efforts made in Andalusia in this sector. There are 19 research institutions devoted to functional foods research. One of them (University of Granada) accounts for the third highest scientific production on functional foods issues in Spain with a total of 226 publications over the period 1990–2004. The *Instituto de la Grasa* (Fats Research Institute) in Seville and the Universities of Cordoba and Seville together produced a similar number of articles to the University of Granada.

The rest of the scientific research was provided by a total of 15 private and public institutions (see Fig. 1). In a province-by-province analysis, the province of Granada is particularly dominant with more than half of the total research on nutrition and dietetics followed by Seville and Cordoba, while the other five provinces provide 6.3% of the total research. Public investment in Biotechnology R&D by the regional government (*Junta de Andalucía*) in 2007 was 103.8 million Euros (a 50% increase compared to 2006). This level of investment put Andalusia in third place in the national ranking after Madrid (€369 million) and Catalonia (€300 million). 77% of the total investment is devoted to University and other research centre investigation. Functional foods research accounts for 37% of the total investment in biotechnology (€37.2 million) (INE, 2009).

The intraregional indicator (IR) provides information about the internal differences within Andalusian provinces as shown in Fig. 2. Granada scores as the highest province in functional food companies (F) with a total of 13 and Scientific Publications (SP) with 328. Most research groups on nutrition and dietetics issues are located in Granada (16) and Seville (17) out of a total of 49 in the whole of Andalusia (see Fig. 2). The differences between provinces are remarkable with IR indicators of 0.62 for Málaga or 1.04 for Huelva. Seville holds second position ($IR = 38.20$). Most research groups in Andalusia cover more than one research area. There are four main research areas in the R&D on functional foods for the Andalusia region, namely Agriculture and Food, Health Technologies and Sciences, Life Sciences and Physics, Chemistry and Mathematics. The main research lines within Agriculture and Food are Animal Nutrition, Oils and Fats, Genetic Modifications of Plants for Nutritional Uses, Meats, Viticulture, Cereals, Functional Ingredients, Human Nutrition, Food Quality and Toxicity and Food Technologies with 37 research groups devoted to these research lines. Health Technologies and Sciences research lines focus on Microbiology and Immunology, Pharmacognosy, Endocrinology and Metabolism, Pharmacology, Infancy and Clinic Nutrition, Therapeutic Implications of Fats and Nutritional Diseases with a total of 19 dedicated research groups. Life Sciences is the third research area and focuses on Microalgae Biotechnology, Interactions of Plants and Microorganisms, Antioxidants, Microbial Immunology, Lipids Metabolism and Cellular Biochemistry with a total of 12 research groups. Finally, six research groups are working in the fourth research area of Physics, Chemistry and Mathematics with the following research lines: Isolation, Structural Determination and Synthesis of Natural Products, Environmental, Biochemical and Food Analytic Control, and Pharmacologically Active Molecules.

Research groups base their activity on private and publicly funded projects. About 20% of the total financing comes from research contracts with private companies, while the rest comes from regional, European and National public projects. In 2006 more than 20% of all National R&D projects related to functional foods were developed by Andalusian research groups, the highest figure in Spain together with the Madrid region which has much higher levels of wealth and economic development (See *INE economics indicators*, 2007). Within Spain as a whole, there has been a remarkable increase in the number of publications in food science in the last 10 years. In 1996, Spain presented 12.8% of all Western European publications on food science. By 2007 this figure had increased to 18.3%. Fig. 3 shows trends in publications for Western Europe (including Spain), North America and Spain. Almost 10% of Spanish food science publications are produced in Andalusia (SCImago, 2009).

The protection of scientific and technological advances through patents is particularly important in the fields of biotechnology, pharmaceuticals and nutrition. For the period 1997–2008 more than 20% of patents by research groups from the Andalusian Uni-

Table 1
Employment and sales figures for the food industry in the different Spanish regions.

Spanish region	Employees	Employment (%)	Product sales (million €)	Product sales (%)
Andalucía	52,175	13.8	12,047	14.7
Aragón	11,259	3.0	2669	3.3
Asturias	8436	2.2	1819	2.2
Balearic Islands	4488	1.2	541	0.7
Canary Islands	10,600	2.8	1358	1.7
Cantabria	5800	1.5	948	1.2
Castilla y León	38,121	10.1	7835	9.5
Castilla-La Mancha	23,469	6.2	6324	7.7
Catalonia	75,746	20.0	18,110	22.1
C. Valenciana	33,380	8.8	6728	8.2
Extremadura	10,260	2.7	1904	2.3
Galicia	28,712	7.6	6452	7.9
Madrid	20,012	5.3	3951	4.8
Murcia	20,961	5.5	3816	4.6
Navarra	12,305	3.3	2593	3.2
Basque country	15,209	4.0	3212	3.9
La Rioja	6964	1.8	1787	2.2
Total food industry	377,897	100	82,094	100
Total industry	2,580,375		512,603	

Source: Own processing based on the Report of the S.G. Fomento Industrial e Innovación.

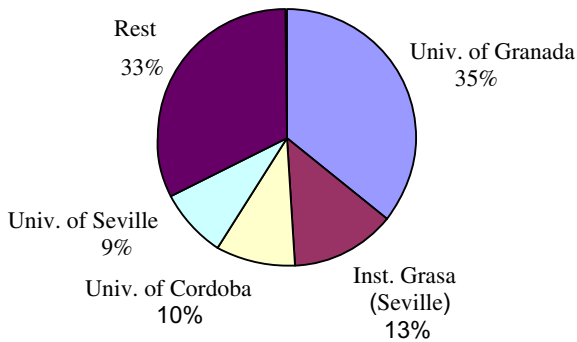


Fig. 1. Scientific production on nutrition and dietetics in Andalusia (1990–2004).

versities were related to these types of advances, with almost 40% in biotechnology, 38% in nutrition and dietetics and 22% in pharmaceuticals (European Patent Network Database, 2008). This

development has occurred alongside regional policy investments to increase funds for research projects and attract top-level researchers to the region. According to the Instituto de Estadística de Andalucía, in 2007, Andalusia had 47 research groups working in food science and nutrition and two research centres. These investments and the growth in the number of specific researchers have attracted an important number of firms from the functional food sector (a total of 29 in 2007, 13 of which are located in Granada). Hence, the interaction between the number of researchers, patents and public investments is bearing positive fruit in the creation of a future food industry cluster.

The increasing interest in functional foods shown by Spanish consumers has led to high rates of growth in the sector (14% a year compared to only 3% for traditional foods). The potential for market expansion in Europe is large, as in the US consumers buy twice as many functional food products as in Europe (REUTERS, 2008). Spain is the 9th country in the world in scientific production on functional foods issues (10th in general terms). Since the year

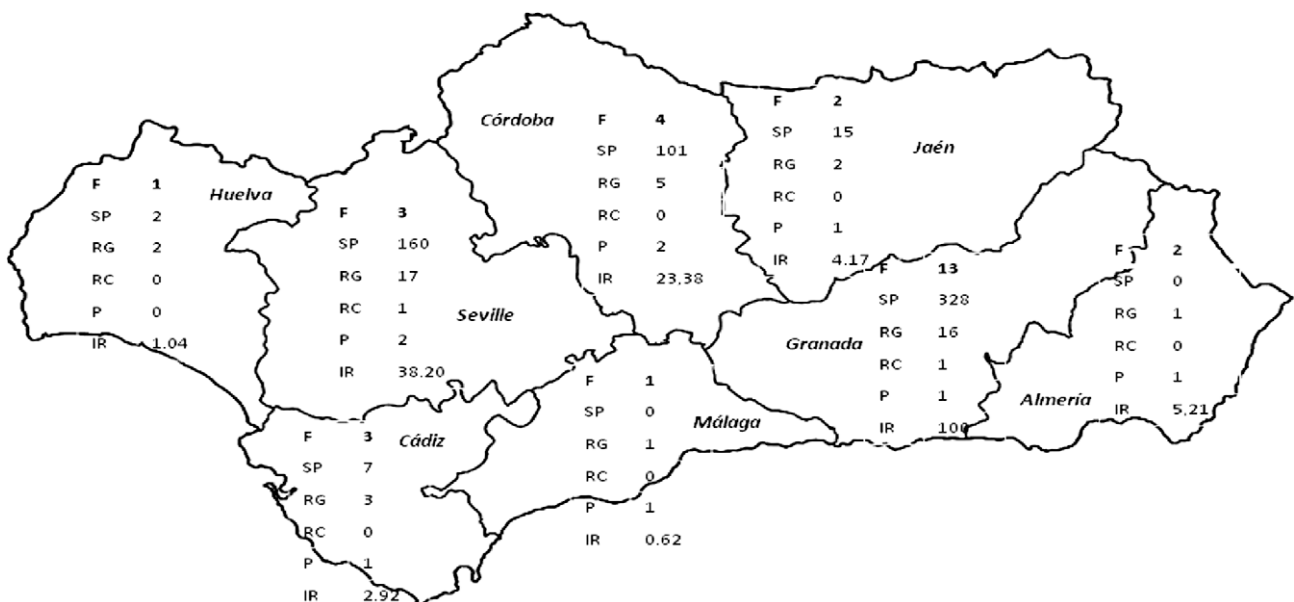


Fig. 2. Intraregional indicators of functional food research and industry.

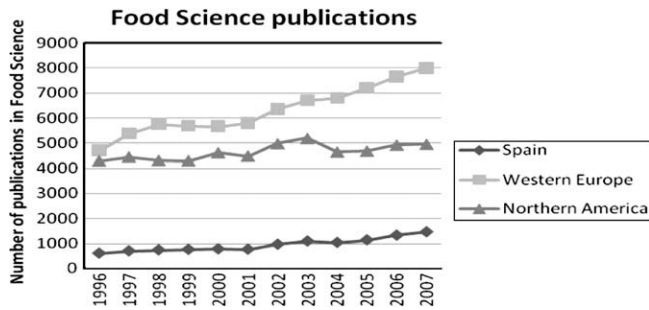


Fig. 3. Food science publications.

2000 Andalusia's Public Universities Council has intervened directly to support the creation of new technology-based firms, with the aid of subsidies from the regional government. These direct actions, which include the creation of technological parks the offering of incentives to establish technological networks involving research groups and companies, and an increase in the number of business incubators, have concentrated most public investment on technological development issues. The whole of Andalusia is covered by the Andalusian Business Support Network (RAAE)¹ with 161 centres all over the region. This network offers resources for firm management training, consultancy and information about public subsidies and collaboration with other institutions and firms. Most regional functional foods firms have made use of the services offered by the RAAE.

Discussion

The European innovation scoreboard (EIS) (EIS Report, 2008) provides a comparative assessment of the innovation performance of EU Member States, under the EU Lisbon Strategy. Cyprus, Estonia, Slovenia, Czech Republic, Spain, Portugal, Greece and Italy are considered as "Moderate innovators", with innovation performance below the EU average. The trend in Cyprus' innovation performance is well above the average for this group, followed by Portugal, while Spain and Italy are not improving their relative position. The growth performance of Cyprus and Greece is the highest of all these countries, while Estonia, Portugal and Spain have also grown faster than the average for the EU27 (EIS Report, 2009).

In this context, the Andalusian situation presents similarities to some of these other European regions in that, despite some time delays in local industry development, economic development is occurring through strong regional policies based on financial support for new ventures (Mulas-Granados and Sanz, 2008). Even though the quality of the functional food research encouraged by local authorities in the region is being reinforced through specific financial programs, the structure of the academic and the industrial systems hinders a productive interchange between the two. Other negative factors such as the relatively low number of spin-off companies created and the general sluggishness of industry in diversifying towards functional food have also played their part. The Andalusian Plan for Research Development and Innovation (Plan Andaluz de Investigación, Desarrollo e Innovación – PAIDI) 2007) was set up in 2007 in part to combat these problems. This is an ambitious strategic and financial regional program that seeks to coordinate and promote research and development policies in Andalusia.

In Andalusia, regional funding of innovation work in both public and private R&D institutions has led to outstanding improvements in attracting investment in specific industries. Nonetheless, the de-

gree of regional development is still far from satisfactory compared to other similar peripheral regions in the European Union, such as the Comunitat Valenciana in Spain (Todt et al., 2007). Although research efforts have produced continuous improvements in the added value of functional food products, the data presented above shows that a strong functional food industry in the Andalusian region is still a long way off. This raises the question as to why there is such a low level of local functional food development in comparison with Central European food industry clusters, despite a relatively intense effort from the public research sector (Todt et al., 2007). Businesses, on the one hand, and science and technology, on the other, have characteristic strengths and weaknesses that make spin-off creation an excellent way to bridge these gaps and an appropriate solution for combining the goals of business and academia. This fact partly fits with the expert opinion that "Nutrition strategy must be led by consumer pull and not science push" (French, 2006). Hence, the intense collaboration between public R&D regional policies and research institutions to offer specific and added value to the sector is crucial in the context of the increasing convergence between nutraceuticals and functional foods. Such convergence is mainly due to the attempts of consumers to cover different nutritional needs with a relatively small number of products (Bröring et al., 2006). Also, efforts oriented towards the market to increase the acceptance of functional food products are fundamental as according to the ACNielsen report, the main reason for customers not buying functional foods is the fact that they are dubious about the claimed health benefits (Anon, 2006).

In this context, local initiatives that aim to convert the fruits of research into commercially successful products are of particular importance. One such project is the science and technology park set up jointly by the University of Granada, the Ministry of Science and Technology and the regional government, which seeks to bring business and academic research together and encourage the creation of spin-off companies. The Granada Health Science Technological Park covers an area of 625,000 m² with 350,000 m² of building land for the different areas, to foster technology transfer between academics and the business sector (PTS, 2009). One of the problems for regional development in this field is that Andalusian functional food research groups and companies often establish links with other players and companies from outside the region. This means that promoting these relationships within the region is a basic need for those wishing to increase Andalusian R&D activity. The Technological Park will help to build networks between local institutions and businesses, in order to improve policy design and management in R&D, foster innovation, and promote education and training. Our previous analysis has shown that many scientific groups of international excellence are already located in the region. The Park could therefore attract the attention not only of those regionally active technology-oriented companies that contract out R&D but also of external agents from both public and private spheres at an international level.

Historically, spin-offs emerged as a third way of commercializing the scientific knowledge produced in universities, after R&D contracts and patent licensing. Chronologically, in Andalusia and Spain, they date back to the end of the 1990s when universities had to face new challenges with regard to the definition and creation of a new marketing approach and strategy that would efficiently commercialize academic research results. However, only universities with a sufficiently consistent research basis can hope to run transfer programmes or units efficiently. University-based scientific inventions that translate into spin-off companies represent a potentially important and increasingly used option to create wealth from the commercialization of research (Clarysse et al., 2005; Lockett et al., 2005; Vohora et al., 2004). Spin-offs could be a solution for the development of a locally oriented industrial

¹ See <<http://www.a-emprende.net/>>.

structure in functional foods, since they represent new R&D cooperation strategies and contribute to improve the interest in protecting the rights of researchers' intellectual and industrial property (Gertner et al., 2007). Regarding the relationship between academic and market focused knowledge, Elco Van Burg et al. (2008) proposed a science-based design approach to the creation of university spin-offs and explained how an emergent design approach developed at a particular university could enhance the ability to create more university spin-offs.

However, according to Díaz et al. (2002), both business and public institutions are often unreceptive to new ideas and unwilling to embark on new projects, a fact that is further compounded by a general reticence on the part of Spanish industry to invest in human resources and hire qualified personnel, as well as by the low levels of investment in in-house R&D. According to the latest available data on R&D activities in Spain, in 2006 the country invested more than 10,000 million euros or 1.2% of its GDP in R&D. Despite this positive figure, Spain still lags far behind the European average (EU-15) of 1.98% for the same year. However, it is important to emphasize that the EU-25 average has remained stable or suffered slight declines over the last 5 years, while the trend in Spanish R&D investment is clearly rising (CDTI, 2006).

In addition, as in other Mediterranean regions, Andalusian entrepreneurs tend to view tourism and construction as the best economic motors for their regions (AECA, 2003) and members of the academic community do not usually create start-ups or spin-off companies (CDTI, 2005). In Spain, new university graduates have normally had little direct contact with or experience of business nor have they received an education aimed at fomenting an entrepreneurial mindset (García-Aracil et al., 2004), while University lecturers/researchers are rewarded according to their scientific output (Todt et al., 2007) and are even faced with certain legal obstacles that prevent them from setting up companies. However, more importantly, even if such companies could be created, their focus often tends to be supra-regional, with many companies moving outside the region when offered other incentives (Todt et al., 2007).

Conclusions

Even though the Andalusian economy depends to a large extent on services and construction, significant advances have been achieved in promoting R&D policies to support the creation of industrial clusters based on innovative technologies such as the Andalusia Biotechnology Cluster.² In this context, Andalusian public policies for research in the functional foods sector have achieved significant results. However, this fact does not decisively influence regional company creation or innovative activities, since there is an important gap in functional foods research between dominant research-oriented and weak application-oriented activity. Public policies to support the creation of a food industry cluster by fostering entrepreneurship and attracting global industries is crucial to obtain a satisfactory performance from financial efforts devoted to knowledge transfer from research institutions.

The few existing functional foods-related companies that do invest in their own R&D still have very limited relationships and knowledge transfers to and from academic research groups in the region. Most of their research needs are being outsourced to public and private institutions from outside Andalusia. This situation is however progressively changing as many scientific groups of international excellence are being attracted to the region, in order to capture the attention of global functional food companies. The

development of this industry at a regional level in order to diminish Andalusia's dependence on the construction and tourism sectors requires at least the following conditions: (1) important public policies to solve the deficiencies of the regional functional foods sector by promoting strategic centres in Andalusia for knowledge generation and application in industry, (2) encouraging a spirit of entrepreneurship (helping the researchers to develop business projects in collaboration with research institutions and leading functional foods firms in the form of start-ups and spin-offs).

Data from this paper suggest that in order to take advantage of the potential of the Andalusian region, public institutions would have to focus their efforts and funds on: (1) Fostering relations between regional social players that lead to the creation of durable links that go beyond initiatives such as the creation of clusters at different levels. (2) Increasing the entrepreneurial spirit of university students/researchers (a revised legal framework has recently been approved). (3) Promoting and improving the quantity and quality of international excellence research groups. (4) Stimulating the creation of scientific and technological parks where spin-off companies can contribute to increase wealth and economic growth in the region. Future lines of research include further analysis on the interaction between regional strategic clusters in order to develop research policies for knowledge generation and sharing. In addition, specific regulatory issues need to be studied in order to analyse the attractiveness of a region for global firms when locating industrial plants in the context of technological clusters.

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² See <www.agenciaidea.es> and <www.juntadeandalucia.es/innovacioncienciayempresa>.

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