DIFFERENCES IN INNOVATION BETWEEN FOOD AND MANUFACTURING FIRMS: AN ANALYSIS OF PERSISTENCE

Maria C. Cuerva
University of Castilla-La Mancha
Department of International Economics
Faculty of Economics and Business
02071, Albacete (Spain)
Phone: 34 967 59 92 00 (ext. 2371)
e-mail: mariac.cuerva@uclm.es

Ángela Triguero-Cano
University of Castilla-La Mancha
Department of International Economics
Faculty of Economics and Business
02071, Albacete (Spain)
Phone: 34 967 59 92 00 (ext. 2380)
e-mail: angela.triguero@uclm.es

David Córcoles
University of Castilla-La Mancha
Department of International Economics
Faculty of Economics and Business
02071, Albacete (Spain)
Phone: 34 967 59 92 00 (ext. 2371)
e-mail: david.corcoles@uclm.es

Abstract:

This paper examines the differences in the behaviour of the innovation between the Spanish agro-food and manufacturing firms, using firm-level data provided by the `Survey on Business Strategies´ (ESEE) from 1990-2008. The aim is to analyse the persistence in innovation and to explore the explanatory determinants of the probability of being product and process innovator. Survival functions, transition probabilities matrixes and dynamic discrete choice panel data models are combined to measure persistence. Our results suggest that in the food industry the persistence of process innovation is higher than product innovation. Environmental and market determinants such as market changes or innovation appropriability are more decisive to explain innovation in food industry. By contrast, several determinant variables for innovation activities in the manufacturing sector seem not to be linked with the innovation in food firms. That is the case of the outsourcing ratio and the positive evolution of market share.

***Keywords*:** persistence of innovation, process and product innovation, transition probability matrix, dynamic discrete choice model, agro food industry.

JEL CODE: L26, L66, O31

Introduction

In the last years the analysis of the relationship between innovation and industrial dynamics has generated a highly set of theoretical and empirical contributions. The progress in new econometrical package and the availability of large panel data at firm level have allowed to identify some stylized facts and empirical regularities related to the high within-industry heterogeneity in innovation (Malerba, 2007). As Dosi (1997) points out innovation heterogeneity across firms denotes the presence of particular capabilities and implies that even when firms do the same thing, they can do it in different ways.

Many of the empirical studies have analysed the innovation's behaviour in manufacturing firms without paying much attention to sector considerations. In this sense, the role of the technology and innovation in the agro food industry has been traditionally relegated (Cadenas and Fernández, 1989). Literature has even showed more interest in agricultural sector than in the agro food sector innovation (Rama, 1996). Although this sector is considered low- tech intensive, evidence supports that firm's returns and growth depend on its capacity to innovate (Connor, 1981; Alfranca et al, 2003). For that reason, the agro food industry is becoming more technology intensive as a result of the biotechnology revolution and the need to maintain better process controls, exploit economies of scale and ensure food safety, variety and quality (Trail and Meulenberg, 2002). This fact explains the growing interest in analysing the innovation behaviour in the agro food sector (Noronha et al, 2006).

A substantial research effort has been devoted to examine the persistence of innovation. Among the most recent researches we find Antonelli et al (2010), Peters (2009), Antonelli and Scellato (2009), Roper and Hewitt-Dundas (2008) and Raymond et al (2010). Nevertheless, studies focused on innovation persistence in the agro food sector are still scarce (Alfranca et al 2002, 2004).

In Spain, food industry is the largest manufacturing sector, employing more than 2.5 million of workers and accounting for 14% of the gross value added of the total manufacturing sector. The number of companies operating in this sector is 25.000, although, more than 40% has less than five employees. The agro food sector is important not only because of its productive function as a supplier of consumer demands, but also it is one of the sectors which help to revitalize rural areas, contribute to the sustainability and to the job creation.

This paper examines the dynamics of innovation in Spanish agro food industry using firm-level data for the period 1990-2008 in order to analyse the persistence in innovation and to explore significant differences compared with the manufacturing sector. The aim is twofold.

First, we test if the past innovation behaviour influences the current innovation, in other words, our hypothesis is that past experience matters. We also are interested in finding out which are the explanatory determinants of probability of being product and process innovator in this particular sector, paying special attention to the differences observed with the manufacturing firms. The literature highlights that successful firms asses their *R&D* and market perceptions to ensure the introduction of technologically innovative products that the market demands (Grunert et al., 1997). However, like Trail and Meulenberg (2002) point out, the literature provides little information on whether the mechanisms and determinants of product and process innovation are the same.

Firm-relative information comes from the Survey on Business Strategies (ESEE hereinafter), published by the Ministry of Science and Technology, which provides data for a considerable number of food and beverage (*F&B*) firms in Spain. The availability of longitudinal firm-level panel data allow us to consider the dynamics features of innovation in a particular sector and compare with the total sample. At the same time, unobserved firm-specific heterogeneity is taken into account.

The contributions of this paper are diverse. First, persistence analyses carried out for the agro food sector in Spain are scarce. As far as we concern, Alfranca et al (2002, 2004) are the only papers which examine this question, but only for multinational firms and using patent data. Therefore, this paper will contribute to the incipient discussion in literature on the persistence of innovation in this particular sector.

Secondly, we examine the dynamics of innovation over time analysing both types of innovation: product and process innovation. To the best of our knowledge, these both types of innovation have not been usually separately considered by other studies in persistence of innovation[1] in manufacturing industry, and, in the case of agro food sector, there is not any paper who examines it.

Other contribution of the paper consists in making a comparison between agro food sector and manufacturing sector as a whole. The purpose of this is to find out if there are significant differences in the innovation behaviour of the food firms.

In relation to the methodology, we approach persistence through the estimation of Transition Probability Matrices, and Survival Functions. Additionally, we estimate a dynamic random effects probit model proposed by Wooldridge (2005). This new method allows to take

[1] As far as we concern, Labeaga and Martinez-Ros (2003) is the only one that analyses the complementarities among several decision of innovating using a bivariate probit. This analysis is focused on the determinants to carry out product and process innovations and uses mainly the resource-based view (RBV) to study these complementarities.

into account the initial conditions of the model's dependent variable and firms´ individual specific effects (unobserved heterogeneity).

The paper is structured as follows: Section 2 provides a framework for the analyses of innovation persistence in the *F&B* sector. Data are described in Section 3, and empirical methodology and results are presented in Section 4. Finally, Section 5 presents the main conclusions and the perspectives in terms of further research.

2. Theoretical and empirical background.

The aim of this section is to review the existing literature in innovation persistence and develop a theoretical framework for our analysis. The innovation literature has broadly highlighted many factors that affect a firm's ability to innovate[2]. We can organize them into experience (persistence) background, innovation strategy (product and/or process innovation), endogenous and exogenous factors. Among endogenous determinants we include internal factors related to firm´s characteristics (size, age, *R&D* expenditure, degree of internationalization,..,). Lastly, exogenous factors include variables referring to market structure, technological policy, geographical location and some specific features of innovation pattern within the food industry.

2.1. The persistence of innovation: empirical evidence

In line with previous studies inter-sector differences in innovation experience are rather invariant across countries and sectors (Malerba and Orsenigo, 1996, 1999; Breschi et al, 2000). The same industries are characterised by remarkably similar patterns of innovative activities supporting the idea that sector patterns of innovation are influenced by technology-specific variables (Cefis and Orsenigo, 2001).

Since Flaig and Stadler (1994), innovative persistence is an important topic in applied industrial organization. A growing number of studies using patent data (Cabagnols et al, 1999; Malerba and Orsenigo, 1999; Cefis and Orsenigo, 2001; Cefis, 2003; Alfranca et al, 2002, 2003, 2004; Jang and Chen, 2011) or innovation data (Geroski et al. 1997; Raymond et al. 2010) reveal that few firms innovate persistently. More specifically, Duguet and Monjon (2002) examine the persistence of innovation in French manufacturing firms over the period 1986-1996. Roger (2004) also reports persistence using a survey of Australian firms conducted from 1994 to 1996. Mañez-Castillejo et al (2004) ascertain the firm persistence in

[2] In this sense, see Griffiths and Webster (2010).

R&D activities using firm-level data for Spanish manufacturing firms in the period 1990-2000. Roper and Hewitt-Dundas (2008) deploy panel-data and case-study approaches for Irish firms over the period 1991-2002. Peters (2009) shows persistent innovation behaviour at the firm-level using data on German manufacturing and service firms for the period 1994–2002[3]. Antonelli et al (2010) confirm the presence of significant persistence in innovation for a sample of 451 Italian manufacturing companies during the years 1998-2006. Finally, Triguero and Córcoles (2010) examine the persistence in innovation input and output in the Spanish manufacturing firms over the period 1990-2006.

However, any of these above-mention papers have considered a particular analysis of the food sector. Alfranca et al (2002, 2004) are the only works which deal with the innovation persistence in the agro food firms. The authors explore whether current innovation has an enduring effect on future innovative activity in large and global food and beverage (*F&B*) companies. By using cointegration techniques, they study a sample of 16,698 patents registered by 103 multinational *F&B* firms over the period 1977-1994. Conclusions confirm that current innovation is related to past innovation among these multinational firms. The empirical evidence contributes to clarify the patterns of technological accumulation in the multinational agrifood industry but not in small and medium agrifood enterprises in a particular country.The present paper also expects to find persistence in innovation, but in our case the considered dependent variables are the likelihood of getting product and process innovation.

2.2. The innovation strategy in the food industry: process innovation, product innovation or both.

Given the recognized complexity of innovation process, the influence of past innovation on current innovation is not the only concern. Firms have to decide their innovation strategy and choose between incremental or radical innovation or both. In this sense, innovation is associated with diverse strategies of firms. Hence, we expect that innovation persistence may vary depending on the different types of innovation considered.

[3] In this sense, Raymond et al. (2010) is the only paper that finds no evidence of true persistence in innovation by estimating a dynamic model accounting for individual effects and initial conditions problem. Although the authors suggest that there is evidence of true persistence of innovation when they measure innovation as an input, they find spurious persistence from the point of view of the innovation as output. This result could be explained by the high correlation between initial conditions and the lagged dependent term (persistence) obtained with a panel data constructed only from three waves of the Community Innovation Surveys (CIS) (periods 1994-1996, 1996-1998, and 1998-2000).

Some related literature indicates that product innovation must be more persistent than process innovation (Antonelli et al., 2010). Product innovations are crucial to maintaining the leadership in most frequent markets (monopolistic competition) characterized by vertical differentiation.

In contrast, Porter (1990) highlights that most innovations are usually `mundane and incremental rather than radical (p.45)´. The former is associated with cumulative improvements on the firm's activities and the latter with the introduction of new technology. Thus, incremental innovation usually involves minor changes in the operational way of the firm and comes from "organisational learning" instead of *R&D* projects which are associated with radical innovation. In this sense, we can expect that most of the innovations will be incremental or non-radical in all the manufacturing sectors, including the *F&B* industry. We realise that incremental innovation is not similar to process innovation and radical innovation is different to product innovation but this aspect is not completely solved in the empirical economic literature.

Some studies show that food firms are process-innovation oriented and incremental innovation predominates over radical (Archibugi et al, 1991; Grunert et al., 1997; García and Briz, 2000; Alfranca et al, 2002; Galizzi and Venturini, 2008). Following Batterink et al (2006), firms focused on market related innovation carry out higher levels of product innovation, whereas firms focused on efficiency related innovation reach higher process innovations. This result could be explained by the `consumer inertia´ effect, a form of persistence whereby consumers have a higher probability of choosing a product that they have purchased in the past. This aversion to new food products could decrease the likelihood of product innovations in the F&B industry. Furthermore, the speed of diffusion of product innovations will be higher than the corresponding to process innovation. The imitation of a new process takes some time but a new product can be easily imitated. However, process innovation could be more persistent in markets characterized by price competition (Antonelli et al., 2010).

Actually, product and process innovations in the food industry are often interdependent activities. Data from de ESEE show that Spanish food companies rarely perform product innovations without performing process innovation at the same time. Indeed, the share of food firms which achieve both product and process innovation (40.2%) is higher than the mean of the manufacturing sector (36.7%) in the period 1990-2008. On the contrary, very few food firms state that they have only carried out product innovation. This fact could indicate that when firms start producing a new product, they predominantly have to undertake major investments in machinery and equipment. It could also indicate that when food companies perform product innovation, they need certain process innovation degree to introduce new production lines which lead to radical innovations. This perspective is also argued in Christensen at al (1996), concluding that food industry has particularly been strong in introducing radical innovations the last two decades[4]. In other words, there are apparently strong complementarities between product and process innovation in the food industry, perhaps much stronger than in other industries.

Another important question to tackle with is how to measure the innovative activities in the agro food industry. Most studies have proxied innovation by input (*R&D* expenditures) or output measures (patents, numbers of innovations). Avermaete (2006) points out that it is hardly possible to study innovation in the European agro food sector based on patents and *R&D* expenditures. Patent data are rare and information about *R&D* expenditures is highly limited. To face this problem we have combined both measures, considering the results of innovation through the attainment of process or/and product innovations and the firm's specific *R&D* effort. The former are introduced as the dependent variables of the models, and the latter is considered as an explanatory variable. As far as we concern, this paper provides the first analysis of persistence in innovation focus on both (product and process innovation) in the food industry. Nevertheless, we are conscious of the absence of satisfactory measures of innovative activity (Cohen and Levin, 1989). For instance, *R&D* investment is not the only expenditure contributing to innovation in the agro food sector (Feigl and Menrad, 2008; García and Briz, 2000; García-Martinez and Burns, 1999; Rama 1996). The purchase of machinery is an important part of the innovation acquisition as well as expenditures in software and in intangible technology. We consider that the measurement problems are mitigated when we analyse innovation output. Furthermore,this variable may reflect a wide range of manifestations of technological change, such as patents, *R&D* expenditures or any other expenditures which lead firms to develop innovative activities.

2.3. Firms resources and capabilities to innovate.

The conceptual framework for analysing persistence in the *F&B* industry is completed with the resource-based view theory (RBV). RBV paradigm serves as means to "examine the link between a firm's internal characteristics and performance" (Barney 1991, p.101). Avermaete et al (2004) and Christensen (2008) use RBV as framework for understanding

[4] Other studies clarify this conclusion and they highlight that radical innovation has been slowly introduced in the food sector (Noronha et al, 2006)

firms' innovation in the food sector. The internal capabilities of small firms are examined to determine their innovative performance (i.e. entrepreneurial characteristics, skills of the workforce and investment in know-how in Avermaete et al. (2004)). Since the persistence depends on resources and capabilities of firms to persevere in innovation, we take also into account the firm´s resources given that they are crucial to determine their competitive advantage. Different authors include tangible, intangible and human resources. For example, Barney (1991) offers a detailed definition of a firm's resources: physical capital (physical technology use in a firm, a firm's plant and equipment, its geographic location, and its raw materials); human capital (training, experience, judgement, intelligence, relationships, and insights of individual managers and workers in a firm); organisational capital (a firm's formal reporting structure, its formal relations among groups within a firm and between a firm and those in its environment´(Barney, 1991, p.101). In this paper, we consider age, skills of the workforce, size and advertising intensity as firms´ internal characteristics.

The above definition provides a framework to identify the kinds of resources available to firms that may be utilised for innovation purposes. In other words, RBV theory let us to know how important these resources are for process and product innovations in firms belong to *F&B* industry. Furthermore, `innovation is very much about the ability of the entrepreneur to look at markets, technologies and business models and to interpret them "differently". Being able to see market and technological opportunities through different lenses (and in new ways) is an important entrepreneurial capability. It enables one to see opportunities that others might miss´ (Augier and Teece, 2007, p.177).

Capability of a firm is also used to determine how a firm develops and sustains its competitive advantages. This is known as `dynamic capabilities´ framework. According to it, dynamic capabilities are linked to a firm's competence to respond to 'changing environment' (`technologies and markets´), by using its resources in different ways. In this context, we consider export orientation, outsourcing status, customers´ concentration, suppliers´ concentration, appropriability ratio and company's market-share evolution as dynamic capabilities of the firms. This view appears useful because it serves to explore firms' capabilities in the context of market dynamics or changes in consumer demands. However, these dynamic capabilities are subject to competition and market factors.

2.4. The influence of competition and environment context.

The relationship between competition status and incentive to introduce a cost-reducing innovation has received considerable attention in the literature (Delbono and Denicolo (1990);

Bester and Petrakis (1993)). Traditional view, associated with Schumpeter (1943), considers market concentration as a stimulus to innovate. On the contrary, Arrow (1962) claims that incentive to innovate would be greater in more competitive markets[5]. Antonelli and Scellato (2009) point out that the persistence of innovation takes place when the competitive pressure pushes firms to react changing their technologies instead of adjusting prices. In relation with the food industry, Culberston and Mueller (1985) find that *R&D* activities decrease with market concentration. A wide range of issues have been analyzed, from incentives to innovate in several market structures to spillover effects (De Bondt, 1997). However, factors that might be important in a firm's decision whether to invest in product innovation (improvement in the quality of its product) or process innovation (cost reduction) has received little attention (Rosenkrantz, 1995, Bonanno and Haworth, 1996; Mantovani, 2006).

In relation to geographical location, many studies have analysed the link between territory and innovation behaviour from the hypothesis that local or regional economic environment may help explain why some firms are more innovative than others (see Segarra, 2009). Nevertheless, conclusions are diverse and discussion continues. Some studies point out that firm-related factors are more important for innovation that regional factors (Beugelsdijk, 2007; Fritsch, 2004; Stenberg and Arndt, 2001; Rama, 1999). Other ones conclude that there is not a strong relation between location and innovation (Fritsch and Franke, 2004; Avermaete et al 2003; Love and Roper, 1999). And we can also find papers where *R&D spillovers* are bounded by geographic distance (Goncalves and Almeida, 2009; Simonen and McCann, 2008; Cabrer-Borras y Serrano-Domingo, 2007; Bottazzi and Peri, 2003; Acs et al, 2002; Kleinknecht and Poot, 1992).

3. The data and empirical methodology.

3.1 - The data

The data are provided by the `Survey on Business Strategies´ (ESEE) financed by Ministry of Industry, Tourism and Trade, Fundación SEPI and Fundación ICO. The sample is representative of Spanish manufacturing firms with more than 10 employees and covers the period from 1990 to 2008 for more than 4,000 firms. According to the manufacturing classification, food firms are the most numerous ones, with a panel data of 535 firms.

The ESEE collects information about the introduction of product and process innovations with other firm characteristics. It includes variables related to product and process

[5] However, Arrow considers a particular case of a firm that cannot be imitated by competitors.

innovations and several characteristics regarding customers and suppliers, markets, foreign trade and employment. It also includes some characteristics of the company and its activities, such as its industrial and non-industrial facilities, its legal structure and some of the significant participations in its social capital, activity and characteristics of the manufactured products. Therefore, the sample allows to know and analyze in depth the evolution across time of the innovation process.

One of the most relevant characteristics of the ESEE is its representativeness. The firm selection was carried out combining exhaustiveness and random sampling criteria. Firms are classified into two categories. The first one includes those which have over 200 employees. The second one is composed of a randomly selected sample of firms which employ between 10 and 200 workers.

Table 1 reports the main descriptive statistics. The definitions of the variables are shown in the Appendix. Given that our main interest is the innovation performance, we define two dummies as dependent variables. The first one equals 1 if the firm has introduced a product innovation and zero otherwise. The second dummy equals 1 if the firm is a process 'innovator' (a firm that has introduced a process innovation) and zero otherwise. Two conclusions can be drawn from the Table 1. Firstly, product innovation is less frequent than innovation process in both sectors: *F&B* and total manufacturing. Secondly, *F&B* firms seem to innovate less than the rest of manufacturing enterprises. About 22% of firms register product innovation (24% in total manufacturing industry) and 31% innovates in process innovation (32% in total manufacturing sector).

Nevertheless, differences appear according to the size. In this sense, product and process innovation register higher values in *F&B* firms with more than 200 workers. In particular, 40% and 50% of larger *F&B* firms carry out product and process innovations respectively, as opposed to 39% and 49% in total manufacturing. These results suggest that the small size may be an entry barrier to innovation for the *F&B* industry (Garcia and Briz, 2000).

Table 1. Descriptive statistics for product and process innovation

Total firms														
	Food & Beverages							Total manufacturing industry						
	#Obs. (firms)	Mean	Std.Dev			Min	Max	#Obs. (firms)	Mean	Std.Dev.			Min	Max
			Overall	Between	Within					Overall	Between	Within		
Innovation Product	5,115 (671)	0.221	0.415	0.299	0.308	0.0	1.0	34,831 (4,627)	0.243	0.429	0.316	0.312	0.0	1.0
Innovation Process	5,115 (671)	0.316	0.465	0.351	0.357	0.0	1.0	34,822 (4,627)	0.325	0.469	0.331	0.365	0.0	1.0
Firms with, at least, 200 employees														
	Food & Beverages							Total manufacturing industry						
	#Obs. (firms)	Mean	Std.Dev			Min	Max	#Obs. (firms)	Mean	Std.Dev.			Min	Max
			Overall	Between	Within					Overall	Between	Within		
Innovation Product	1,692 (229)	0.406	0.491	0.357	0.371	0.0	1.0	10,758 (1,371)	0.387	0.487	0.359	0.367	0.0	1.0
Innovation Process	1,692 (229)	0.503	0.500	0.348	0.399	0.0	1.0	10,759 (1,371)	0.495	0.500	0.349	0.399	0.0	1.0

Source: ESEE

3.2. Descriptive analysis based on Transition Probability Matrixes and survival functions of innovation.

This section provides descriptive evidence on the extent of innovation persistence, using transition probability matrixes (TPM) and survival functions. This methodology allows us to measure how innovation persist or change over time.

Following Cefis (2003) it is possible to model the sequence of innovation and non-innovation states as a stochastic process approximated by a two-state Markov chain with transition probabilities:

$$P[X_t = i \mid X_{t-1} = j] = \begin{bmatrix} p, (1-p) \\ (1-q), q \end{bmatrix} \qquad (1)$$

The corresponding *AR(1)* process for the stochastic variable X_t is the following:

$$X_t = (1-q) + \rho X_{t-1} + \upsilon_t \qquad (2)$$

where ρ =*p*+*q*-*1*

Each term of the (2X2) TPM will be the conditional probability:

$$p_{ij} = P(I_t = j \mid I_{t-1} = i) \tag{3}$$

or the probability of moving from state *i* to state *j*.

Table 2 reports the TPMs for product and process innovation considering the *F&B* data and the whole sample of manufacturing firms between period t and *t-1*, and *t* and *t-5*. We find that both types of firms have difficulties to access innovation: around 90% of non-product innovators in *t-1* period maintain this *status* in *t*, while this share is lightly minor for the non-process innovators (84%). Therefore, persistence is high both product and process innovation. On the other hand, the probability of innovating in two subsequent years is above 60% independently of the manufacturing industry considered and the type of innovation. Nevertheless, there are some differences between *F&B* and total manufacturing firms. While the persistence of product innovation is higher than process innovation in total manufacturing industry, the opposite occurs in the *F&B* sector. Thus, the *F&B* firms are more persistent in process innovation to obtain leading positions in markets. Despite the fact the probability of persistence in the same state diminishes, the five-year transition matrices still show high level of innovation persistence. More than 45% of innovators keep their positions after five years in both *F&B* and total manufacturing firms. As in one-year transitions, innovation process prevails over innovation product in *F&B* firms.

Table 2.Transition Probability Matrices for product and process innovation

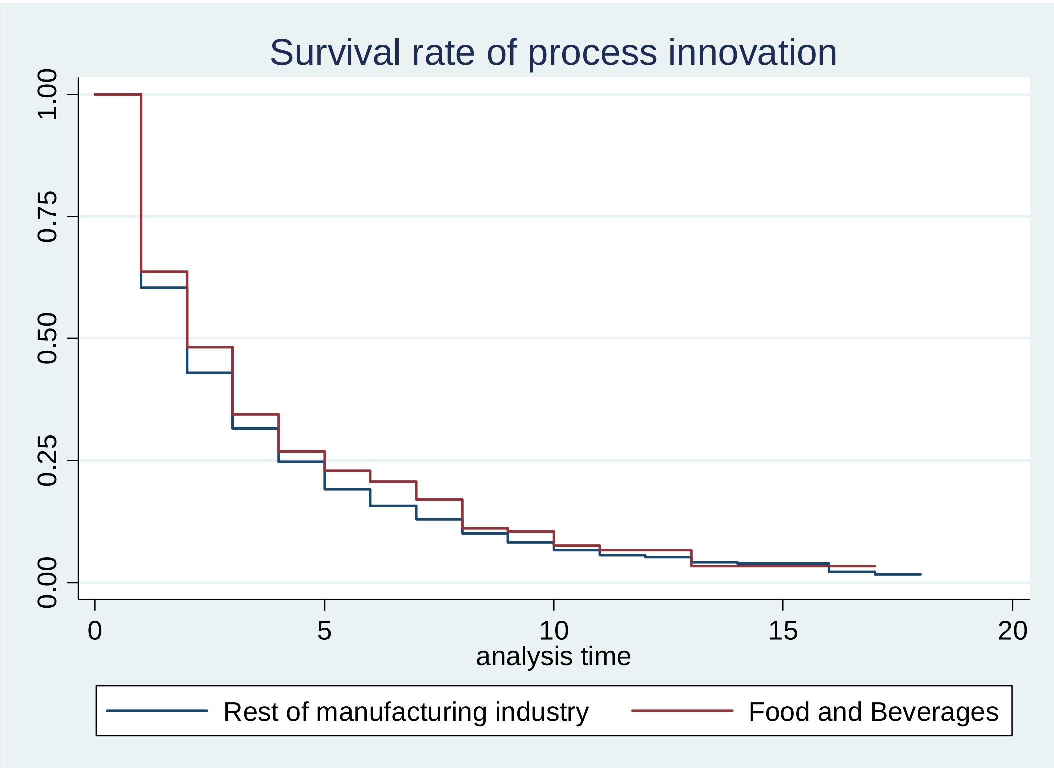
	Product Innovation				**Process Innovation**			
	Non-innovator		***Innovator***		***Non-innovator***		***Innovator***	
	Food & Beverages	*Manufacturing industry*	*Food & Beverages*	*Manufacturing industry*	*Food & Beverages*	*Manufacturing industry*	*Food & Beverages*	*Manufacturing industry*
One year transition								
Non-innovator	90.13	89.68	9.87	10.32	84.11	83.46	15.89	16.54
Innovator	35.29	32.43	64.71	67.57	32.72	33.82	67.28	66.18
Five year transition								
Non-innovator	86.62	84.61	13.38	15.39	79.02	76.95	20.98	23.05
Innovator	53.62	50.35	46.38	49.65	50.25	51.59	49.75	48.41

Source:ESEE

The estimated survival functions of product and process innovation (Figures 1 and 2) show the probability of maintaining the innovation strategy across time. This approach offers an alternative point of view on the persistence of innovation. Additionally, Wilcoxon and

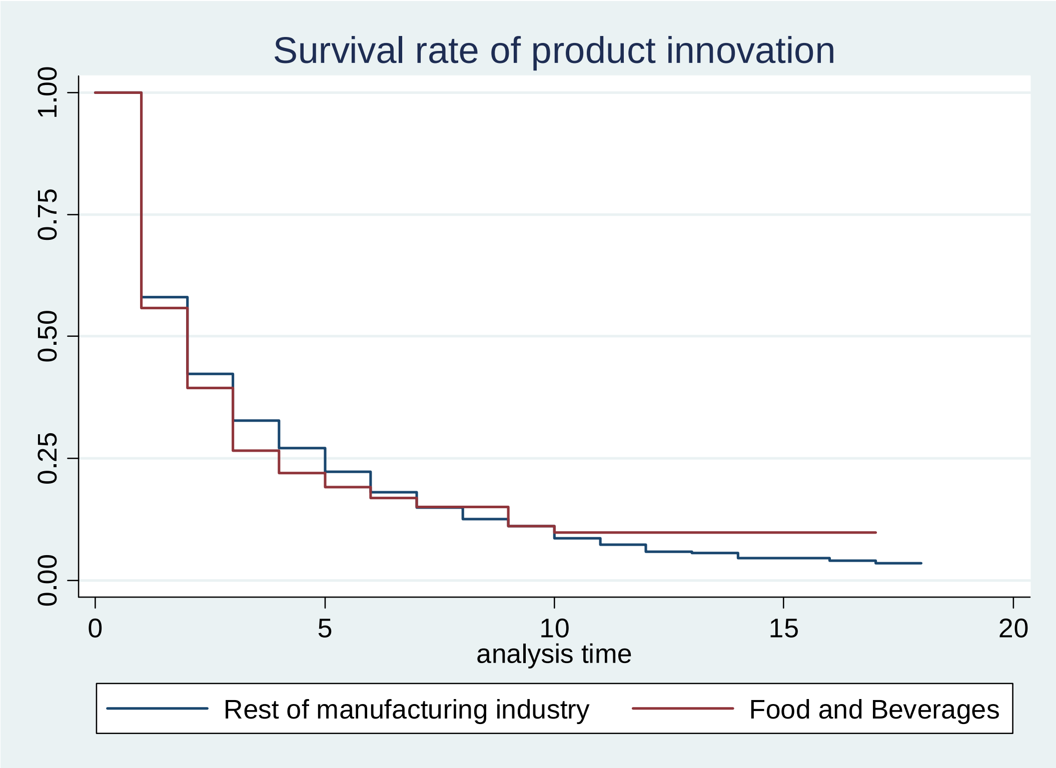
Long-Rank tests are computed to contrast if differences between each group of firms are statistically significant. In line with the TPMs results, Figure 1 shows that process innovation is determinant in *F&B* industry. Furthermore, the path of this type of innovation differs to the total manufacturing industry. From second year onwards, the survival curve of process innovation in *F&B* firms is above the curve of the rest of manufacturing firms. In other words, *F&B* firms are more prone to consolidate process innovation than the mean of manufacturing sector. The results in product innovation (Figure 2) are very similar between both survival curves. Log Rank and Wilcoxon tests confirm the different performance of the *F&B* industry to explain the innovation process (both test significant at the 99% level). For *F&B* firms, innovation constitutes a competitive advantage which reduces the risk of market exit.

Figure 1. Survival function of process innovation



Long-rank test: 4.38** (0.036) Wilcoxon test: 4.09**(0.043)

Figure 2. Survival function of product innovation



Long-rank test: 0.82(0.366) Wilcoxon test: 1.43 (0.232)

4. Econometric analysis

4.1. Empirical Methodology.

In order to estimate the persistence of product and process innovation in the *F&B* industry, we will use a new econometric methodology which allows us to contemplate the initial conditions and unobserved heterogeneity. This model is known as a random effects dynamic probit model. In a dynamic probit model the probability of the outcome variable in a given period is dependent on the outcome in the previous time period and the initial conditions are taken into account. We estimate the following empirical model:

$$y^*_{it} = \gamma y_{i,t-1} + X_{it}\beta + \varepsilon_i + u_{it} \tag{4}$$

Being I =1,…, N *and* t= 1,…,T where the subscript I indexes firms and t indexes time periods. In our setting, y^*_{it} would be the observed binary outcome variable:

$$y^*_{it} = Pr(Iprod_{it} = 1) \text{ if } Iprod_{it}^* > 0; \ 0 \text{ otherwise} \tag{5}$$

$$y^*_{it} = Pr(Iproc_{it} = 1) \ \text{if} \ Iproc_{it}^* > 0; \ 0 \ \text{otherwise} \tag{6}$$

X_{it} is a vector of explanatory variables (see Table A1 in the Appendix) and ε_i are the individual-specific time-invariant terms. Correlation with the observed characteristics is allowed by assuming a relationship of the form $\varepsilon_i = \overline{X_i}a + \alpha_i$, where $\alpha_i \sim iid\ N(0, \sigma^2_\alpha)$ and is independent of X_{it} and u_{it} for all i and t. (Mundlak, 1978 and Chamberlain, 1984). Therefore, equation (4) is rewritten as:

$$y^*_{it} = \gamma y_{i,t-1} + X_{it}\beta + \overline{X_{it}}a + \alpha_i + u_{it} \tag{7}$$

The level of persistence in the dependent variable is given by γ, being γ>0, in such a way that the higher is the value of γ, the higher is the level of persistence.

Additionally, we assume the serially independent error term $u_{it} \sim N(0, \sigma^2_u)$ in such a way that the error term $v_{it} = \alpha_i + u_{it}$ is equally correlated in whatever two different periods:

$$\rho = Corr(v_{it}, v_{is}) = \frac{\sigma^2_\alpha}{\sigma^2_\alpha + \sigma^2_u} \tag{8}$$

In this context, ρ shows the percentage of total variance explained by the unobserved heterogeneity.

The estimation of the model requires an assumption about the initial observation and in particular on their relationship with the individual-specific terms. Wooldridge (2005) proposes an alternative Conditional Maximum Likelihood estimator under the hypothesis of initial conditions exogeneity. In this scheme the relationship between α_i and y_{i1} is:

$$\alpha_i = b_0 + b_1 y_{i1} + \zeta_i \tag{9}$$

and the underlying model can be specified as:

$$y^*_{it} = \gamma y_{i,t-1} + X_{it}\beta + \overline{X_{it}}a + b_0 + b_1 y_{i1} + \zeta_{ii} + u_{it} \tag{10}$$

We present our results for two different specifications. Firstly, a random effects dynamic probit is estimated where we introduce lagged endogenous variables. Secondly, we display an alternative specification where we also consider the initial conditions of the dependent variables and the individual-specific effects (Wooldridge approach). By consecutive estimations of both models in the *F&B* and in the whole industry, we intend to analyze the level of persistence in the product and process innovation.

4.2. Results.

Table 3 shows the results of the different specifications abovementioned: simple random effect dynamic and Wooldridge probit estimations for *F&B* industry and the whole sample of manufacturing industries. The unobservable percentage of total variance explained (the rho value) is lower in the Wooldridge estimation, except in the case of the process innovation for the *F&B* industry.

In broad terms, the coefficients of the lagged dependent variables are rather similar in the two samples but, in line with the TPM results, the degree of persistence of process innovation is slightly larger than the persistence in product innovation. Comparing both sectors, persistence in process innovation is higher in *F&B* industry (0.36) than in total manufacturing firms (0.35). In other words, process innovation is the most stable innovation strategy in the *F&B* firms. The coefficients associated with the initial conditions in the Wooldridge estimation are similar to the random effect dynamic model. Nevertheless, they are only significant for the total manufacturing sector.

Regarding to the innovation determinant factors, in general, firms' resources and capabilities and environmental and market determinants have the expected signs. The highest incentives to innovate are presented in firms which practice intensive competitive strategies (size, *R&D*, exports) and belong to more dynamic sectors. Probability of innovating in *F&B* sector depends more on the environment than in the case of the whole manufacturing sector, but the level of significance of the variables related to the firm's resources and capabilities is lower. When we compare both types of innovation, the efforts of the *F&B* sector seem to be more addressed to process innovations: variables with significant coefficient have higher values in the estimation of the process innovation.

Among the internal firms´ resources and capabilities, R&D increases the innovation probability but the coefficient associated with the product innovation is less important in the *F&B* industry (0.093 in the *F&B* industry versus 0.114 in the whole sample). These results suggest that *R&D* strategy is mainly focused on the process innovation. Nevertheless we find a significant difference in the relation between *R&D* and innovation when the time-averaged effect (*Av.I+D* variable in the Wooldridge correction) is considered: *Av.I+D* coefficient is positive and significant at 99% level and $I+D_{t-1}$ coefficient is not significant. The effect of persistent *R&D* expenses across time on innovation is higher than the effect of *R&D* effort in the previous year, especially in the *F&B* sector for the product innovation. This fact means that the achieved effort in *R&D* in the previous year is more important for the process innovation whereas product innovation is more affected by the cumulative improvements on the firm's *R&D* activities. That could be indicating two conclusions. First, in this sector product incremental innovation is more usual than radical innovation. Secondly, process innovation in certain years tends to increase the probability of achieving product innovation.

In relation to the firm experience, neither of the two types of innovation is linked to firm age neither in *F&B* industry nor in the whole industry. Variables used as proxies for human capital quality are not significant in the food industry. By contrast, human resources are determinant factors to explain the product innovation in the whole sample.

When size is considered, larger firms are more likely to introduce product and process innovation (positive and significant coefficient). Furthermore, this probability does not statistically differ between *F&B* and total manufacturing firms. This confirms the traditional view about a direct size-innovation relationship (Cohen, 1995; Molero y Buesa, 1998; Cefis and Orsenigo, 2001; Rama and Von Tunzelmann, 2008). Additionally, we introduce squared size as explanatory variable. In this case, the comparison between both sectors suggests different patterns. Hence, size squared is only significant to explain the process innovation in the *F&B* firms while it matters in both types of innovation when we consider the manufacturing sector as a whole. In broad terms, these results are in line with previous literature (Cassiman and Veugelers, 1999; González et al. 2004) suggesting that large firms are more prone to innovate due to economies of scale in research, greater efficiency in its implementation, diversification of implied risk and more financial resources (Acs and Audretsch, 1990). Advertising intensity contributes similarly in the two samples. But it is only positive and significant (at 95% level) for product innovation in the first estimation (dynamic ramdon effect probit).

Export variable has the expected sign. The openness to international markets is an incentive to get product and specially, process innovation. Being an exporter increases around 4% the probability of getting product innovation and 5% for the process innovation (6% and 6.6% for the whole sample, respectively). This result supports the positive association between exports and *R&D* activities found in numerous empirical studies (Cassiman and Veugelers, 1999; Beneito, 2003; López and García, 2005). However, when we estimate the Wooldridge´s model export performance does not explain the innovation path in any industry.

The experience as an exporter (*Av.export* variable) is only relevant for process innovation in food firms.

Regarding to the effects of outsourcing on the probability of being innovator, we obtain that it is not significant in the food industry while outsourcing is a determinant factor in the total manufacturing industry in both types of innovation.

Customers´ concentration only affects negatively to product innovation in the whole industry. While suppliers´ concentration affects negatively innovation process in the manufacturing industry, a higher share of purchases from the three biggest suppliers increases the likelihood of innovation in the *F&B* industry. However, as we expected, the higher is the dependence on suppliers across time, the lower is the probability of getting product and process innovation (*Av.Cprov* variable negative and significant in the *F&B* industry). These results suggest that the link between *F&B* industry and its main suppliers (mainly agricultural sector) could be decisive to explain the innovation gap with the rest of manufacturing industry. Finally, we find that when the firm increases its market power (SHAREVEVO1=1) the likelihood of product and process innovation enhances in the whole manufacturing industry (especially in process innovation) but this effect is not appreciated in the *F&B* industry.

As we have commented above, environmental and market determinants are more decisive in the *F&B* industry, especially in the process innovation. Firstly, appropriability conditions of innovation (measured as number of firm's patents over total innovators) determine the probability of being an innovator, particularly in terms of process innovation, to a large extend. This fact does not occur in the case of total manufacturing industry. If the appropriability ratio increases 1%, the probability of process innovation increases around 50%. This result supports the conclusions of other analyses where firms belonging to low-level innovative industries (as food or clothing industries) with some patent obtain a strong innovation advantage (Tunzelmann and Acha, 2005).

In *F&B* industry, expansive markets increase around 5% the probability of product innovation and around 10% for process innovation. In the whole sample, market dynamism is only significant to explain the likelihood of process innovations (the probability increases around 5.5%).

Finally, market changes (competitor prices, import prices and demand change are proxied by *CM1* variable) increase the probability of getting product and process innovations both in F&B and in total manufacturing industry. Again, this effect appears to be greater in the *F&B* firms. By contrast, neither local nor regional spillovers are significant in any industry.

Table 3. Marginal Effects from Dynamic Random Effects Probit

	F&B INDUSTRY				TOTAL MANUFACTURING			
	IPROD		IPROC		IPROD		IPROC	
	Xtprobit	Wooldridge	Xtprobit	Wooldridge	Xtprobit	Wooldridge	Xtprobit	Wooldridge
PERSISTENCE								
IPRODt-1	0.340***	0.314***			0.352***	0.326***		
	(0.000)	(0.000)			(0.000)	(0.000)		
IPROC. T-1			0.377***	0.361***			0.365***	0.352***
			(0.000)	(0.000)			(0.000)	(0.000)
INITIAL COND.IPROD		0.025				0.058***		
		(0.238)				(0.000)		
INITIAL COND IPROC.				0.030				0.059***
				(0.241)				(0.000)
FIRMS´RESOURCES AND CAPABILITIES								
R&D $_{t-1}$	0.093***	-0.021	0.123***	0.044	0.114***	0.015*	0.117***	0.017
	(0.000)	(0.300)	(0.000)	(0.153)	(0.000)	(0.095)	(0.000)	(0.133)
AGE	-0.000	0.055	-0.000	0.018	-0.000*	0.006	-0.000	-0.037**
	(0.131)	(0.124)	(0.627)	(0.674)	(0.098)	(0.701)	(0.715)	(0.027)
PIL	0.003	0.003	0.003	0.003	0.001**	0.002**	-0.001	0.000
	(0.115)	(0.185)	(0.170)	(0.345)	(0.021)	(0.026)	(0.174)	(0.833)
PTIM	0.001	-0.001	0.001	-0.001	0.001**	0.000	0.001	0.000
	(0.248)	(0.640)	(0.494)	(0.761)	(0.014)	(0.377)	(0.175)	(0.628)
SIZE	0.000***	0.000*	0.000***	0.000***	0.000***	0.000*	0.000***	0.000***
	(0.000)	(0.073)	(0.000)	(0.007)	(0.000)	(0.057)	(0.000)	(0.000)
SIZE^2	-0.000	0.000	-0.000***	-0.000**	-0.000***	0.000	-0.000***	-0.000*
	(0.228)	(0.404)	(0.001)	(0.032)	(0.005)	(0.972)	(0.000)	(0.066)
ADVERTISING /SALES	0.003**	0.001	0.000	-0.001	0.001**	0.000	0.001	-0.000
	(0.043)	(0.708)	(0.822)	(0.673)	(0.012)	(0.946)	(0.464)	(0.730)
EXPORTS	0.041**	-0.006	0.052**	-0.036	0.060***	0.025**	0.066***	0.026*
	(0.018)	(0.834)	(0.016)	(0.329)	(0.000)	(0.024)	(0.000)	(0.053)
OUTSOURCING	0.039**	0.025	0.012	-0.009	0.042***	0.022***	0.043***	0.030***
	(0.030)	(0.235)	(0.567)	(0.738)	(0.000)	(0.003)	(0.000)	(0.001)
CCLIE	-0.000	-0.000	0.000	0.000	-0.001***	-0.000	0.000	0.000
	(0.759)	(0.741)	(0.346)	(0.991)	(0.000)	(0.780)	(0.121)	(0.458)
CPROV	-0.000	0.001***	-0.000	0.001**	-0.001***	-0.000	-0.000	0.000
	(0.964)	(0.001)	(0.491)	(0.041)	(0.000)	(0.747)	(0.114)	(0.505)
APPROPIABILITY	0.277**	0.163	0.395**	0.454**	0.007	0.002	0.017	0.004
	(0.026)	(0.179)	(0.021)	(0.016)	(0.493)	(0.894)	(0.285)	(0.805)
SHAREVO1 (1)	-0.027	-0.027	0.021	0.016	0.033***	0.028***	0.077***	0.072***
	(0.203)	(0.184)	(0.496)	(0.598)	(0.001)	(0.004)	(0.000)	(0.000)
SHAREVO 2 (1)	-0.034	-0.035*	0.004	0.006	0.001	-0.001	0.030***	0.027***
	(0.103)	(0.095)	(0.874)	(0.827)	(0.946)	(0.877)	(0.003)	(0.008)
ENVIRONMENTAL AND MARKET DETERMINANTS								
DMARKET1 (2)	0.057**	0.049**	0.099***	0.098***	0.007	0.005	0.058***	0.054***
	(0.028)	(0.048)	(0.002)	(0.002)	(0.417)	(0.557)	(0.000)	(0.000)

Table 3 (continued). Marginal Effects from Dynamic Random Effects Probit

DMARKET2 (2)	0.007	0.003	0.037	0.037	-0.014*	-0.013*	0.007	0.005
	(0.725)	(0.858)	(0.146)	(0.145)	(0.059)	(0.077)	(0.461)	(0.591)
CM1 (3)	0.039***	0.039***	0.050***	0.052***	0.021***	0.017***	0.038***	0.034***
	(0.009)	(0.008)	(0.007)	(0.005)	(0.001)	(0.005)	(0.000)	(0.000)
LOCAL SPILLOVERS	0.017	0.015	0.007	0.007	-0.000	0.000	-0.000	-0.000
	(0.304)	(0.443)	(0.740)	(0.784)	(0.968)	(0.409)	(0.177)	(0.282)
REGIONAL SPILLOVERS	-0.000	-0.000	-0.004	-0.003	-0.002*	-0.001	0.001	0.001
	(0.820)	(0.975)	(0.280)	(0.326)	(0.059)	(0.108)	(0.297)	(0.490)
TIME AVERAGED-COVARIATES								
Av. *R&D*		0.235***		0.136***		0.213***		0.208***
		(0.000)		(0.007)		(0.000)		(0.000)
Av.AGE		-0.055		-0.018		-0.007		0.037**
		(0.121)		(0.672)		(0.669)		(0.029)
Av. PIL		-0.004		-0.004		-0.002**		-0.003**
		(0.180)		(0.358)		(0.014)		(0.024)
Av. PTIM		0.004*		0.003		0.000		0.000
		(0.075)		(0.213)		(0.493)		(0.962)
Av. SIZE2		-0.000*		0.000		-0.000		-0.000
		(0.085)		(0.814)		(0.806)		(0.226)
Av. ADVERT/SALES		0.001		0.000		0.004**		0.001
		(0.805)		(0.908)		(0.010)		(0.567)
Av. EXPORT		0.012		0.099**		0.008		0.028
		(0.744)		(0.033)		(0.612)		(0.126)
Av. OUTSOURCING		0.017		0.043		0.036***		0.022
		(0.641)		(0.372)		(0.005)		(0.168)
Av.CCLIE		0.000		0.000		-0.001***		0.000
		(0.836)		(0.547)		(0.001)		(0.912)
Av.CPROV		-0.002***		-0.003***		-0.001**		-0.000
		(0.000)		(0.002)		(0.017)		(0.252)
Av. APPROPIABILITY		0.278		-0.846		0.008		0.041
		(0.423)		(0.106)		(0.777)		(0.262)
Av. LOCAL SPILLOVERS		-0.002		-0.047		-0.002		0.001
		(0.971)		(0.474)		(0.229)		(0.509)
Av. REGIONAL SPILLOVERS		-0.001		0.002		-0.005		0.007
		(0.940)		(0.878)		(0.213)		(0.107)
Observations	4,137	4,137	4,137	4,137	28,009	28,009	28,009	28,008
Number of ordinal	535	535	535	535	3,745	3,745	3,745	3,744
Rho	0.166	0.155	0.116	0.123	0.195	0.194	0.140	0.138

* p>0.90; **p>0.95; *** p>0.99
(1) Reference SHAREVO3. (2) Reference DMARKET3 (3) Reference CM2.
Control variables omitted in the table: NACECLIO1_NACECLIO19 for the whole manufacturing firms and TIME1990_TIME2008 for the two samples of firms
Dymanic Prrbit estimations are based in Gauss-Hermite quadrature approximations using eight quadrature points.
The accuracy of results has been checked using 12 and 16 quadrature points with STATA command quadchk.
Coefficients are calculated in marginal effects.
Source:ESEE

5. Conclusions and further research

In this paper we investigate the degree of firm level persistence of innovation in the Spanish *F&B* sector with the aim of analysing the differences in the behaviour of the dynamics of process and product innovation in the agro food firms compared with the performance in the manufacturing industry as a whole.

Our results confirm significant persistence in innovation activities, rather higher in process innovation, even after accounting for individual effects and initial conditions problem (firm unobservable heterogeneity). Past product/process innovation explains current product/process innovation. Nevertheless, a moderately higher level of persistence is found for process innovation with respect to product innovation in the *F&B* industry (vice versa in the whole industry). Therefore, *F&B* firms tend to be more constant when they come to developing process innovations.

In broad terms, the main difference between food and manufacturing firms in terms of their determinants of innovation lies in the environmental and market- related factors. In *F&B* sector, the probability of innovating depends more on this kind of variables compared with the role played by the firms' resources and capabilities.

There are some firms´ internal characteristics and external factors which explain innovation activities. Being a *R&D* performer, size and market changing dynamics affect the probability to achieve product and process innovation both in *F&B* and in the whole industry.

By contrast, several determinant variables for innovation activities in the manufacturing sector seem not to be linked with the innovation in *F&B* firms. Variables such as outsourcing ratio and a positive evolution of market share do not have explanatory power for the innovative performance in the food firms. In addition, the significance of the export variable is lower in the *F&B* sector, although the export experience is a key factor for process innovation in the agro food sector.

Nevertheless, the innovation behaviour in the food sector is especially conditioned by the crucial role performs by the appropriability ratio and the dynamism and changes in the market. An increasing number of patents per number of innovators and operating in a dynamic market (expansive demand, changes in competitor and import prices) enhance the probability of achieving product and process innovations in the sector. On the other hand, our results also suggest that the higher dependence of the food firms on suppliers across time diminishes the probability to innovate. In this sense, the behind position of the sector in terms of innovative intensity could be explained by the relation between food industry and agricultural sector.

The literature has primarily dealt with the overall innovative activity (that is, the sum of product and process innovation) or one specific type of innovative activity (either process or product innovation). There have been no attempts to explain what factors might be important towards product and process innovation. In this paper we take a first step in the direction of filling this gap, by providing an explanation based on firms´ internal resources and dynamic capabilities and environmental and market determinants.

The analysis results highlight some possible lines of further research. For instance, the important role played in the innovation behavior of the food firms by the suppliers encourages to deeply into the relation between the *F&B* and agricultural sector. Similarly, the high effect of the appropriability condition as a determinant explanatory factor of innovation in *F&B* sector leads to think about the relationship between this technological condition and the incentives to innovate in low-tech intensive sectors. Finally, although this paper considers both aspects of innovation (process and product innovation), further research is needed to investigate the importance of each one of them and whether they are complementary or substitutes in the innovation process. Similarly, there is a need to analyze the effect of both of them on firm performance (productivity, profitability…). This could be very important with a view to industrial policy in this important sector of Spain´s economy and other similar sectors with the aim of encouraging innovative activities and improving the firms' attitudes towards innovation.

6. References.

Acs, Z.J., Audretsch, D.B., 1990. Innovation in large and small firms: An empirical analysis. American Economic Review 78 (4), 678-690.

Acs, Z. J., Anselin, L. and Varga, A. 2002. 'Patents and Innovation Counts as Measures of Regional Production of New Knowledge', Research Policy 31, 1069–1085.

Alfranca, O., Rama, R., and von Tunzelmann, N. 2002. A patent analysis of global food and beverage firms: the persistence of innovation. Agribusiness. An International Journal, 18(3),

Alfranca, O., Rama, R., and Von Tunzekmann, N. 2003. Competitive Behaviour, Design and Technical Innovation in Food and Beverage Multinationals, International Journal of Biotechnology, vol. 5, 3-4: 222-245

Alfranca, O., Rama, R., and Von Tunzelmann, N. 2004. Innovation spells in the multinational agri-food sector. Technovation, 24, 599–614.

Antonelli, C., Crespi, F. and Scellato, G. 2010. "Inside Innovation Persistence: New Evidence from Italian Micro-data" LEI & BRICK - Laboratorio di economia dell'innovazione "Franco

Momigliano" Bureau of Research in Innovation, Complexity and Knowledge, Collegio Carlo Alberto, Working paper No. 10/2010.

Antonelli, C. and Scellato, G. 2009. The Persistence of Innovation: The Italian Evidence. LEI & BRICK - Laboratorio di economia dell'innovazione "Franco Momigliano" Bureau of Research in Innovation, Complexity and Knowledge, Collegio Carlo Alberto, Working paper No. 3/2009.

Archibugi, D., Cesaratto, S., Sirilli, G., 1991. Sources of innovative activities and industrial organization in Italy. Res. Policy 20, 299-313.

Arrow, K. 1962. The Economic Implications of Learning by Doing. Review of Economic Studies, 29 (2)

Augier, M. and Teece, D.J. 2007. Dynamic capabilities and multinational enterprise: Penrosean insights and omissions. Management International Review, Vol. 47. No. 2, 175-192.

Avermaete, T. 2006. Systems of innovation: The case of small food firms in the EU, mimeo

Avermaete, T., Viaene, J., Morgan, E.J. and Crawford, N. (2003). Determinants of innovation in small food firms. European Journal of Innovation Management, 6(1), 8-17

Avermaete, T., Viaene, J., Morgan, E.J., Pitts, E., Crawford, N., and Mahon, D. 2004. Determinants of product and process innovation in small food manufacturing firm. Trends in Food Science & Technolology, Vol. 15, 474- 483.

Barney, J. 1991. Firm resources and sustained competitive advantage. Journal of Management, Vol.17, No. 1, 99-120, 267-286

Batterink, M.H., Wubben, E.F.M. and Omta, S.W.F. 2006. Factors explaining the innovative output of firms in the Dutch agrifood industry, Paper presented at the 7th International Conference on Management in AgriFood Chains and Networks, Ede, The Netherlands, 31 May – 2 June, 2006.

Beneito, P. 2003. Choosing among alternative technological strategies: an empirical analysis of formal sources of innovation. Research Policy 32, 693-713.

Bester, H. and Petrakis, E., 1993. The incentives for cost reduction in a differentiated industry. International Journal of Industrial Organization 11, 519–534.

Beugelsdijk, S. 2007. Entreprenurial culture, regional innovativeness and economic growth. Journal of Evolutionary Economics, 17, 187-210

Bonanno, G. and Haworth, B. 1998. Intensity of competition and the choice between product and process innovation. International Journal of Industrial Organization, 16, 495 – 510.

Bottazzi, L. and Peri, G., 2003. Innovation and spillovers in regions: evidence from European patent data. European Economic Review 47, 687–710

Breschi S., F. Malerba, and L. Orsenigo. 2000. Technological Regimes and Schumpeterian Patterns of Innovation. The Economic Journal, 110, 388-410.

Cabagnols, A., Gay, C., and Le Bas, C., 1999. How Persistently do Firms Innovate? An Evolutionary View. An Empirical Application of Duration Models. CNRS Collection Les Cahiers de l'Innovation n. 00001.

Cabrer-Borras, B. and Serrano-Domingo, G. 2007. Innovation and *R&D* spillover effects in Spanish regions: A spatial approach *Research Policy*, vol. 36, issue 9, 1357-1371

Cadenas, A. and Férnandez, A. (1989). La innovación tecnológica en la industria agroalimentaria: factores socioeconómicos que la condicionan, efectos inducidos y medidas de acción pública pertinentes. Agricultura y Sociedad, 53(4), 171-200

Cassiman, B. and Veugelers, R., 1999. *R&D* cooperation and spillovers: Some empirical evidence. CEPR discussion paper 2330.

Cefis, E., 2003. Is there Persistence in Innovative Activities? International Journal of Industrial Organization 21, 489-515.

Cefis, E. and Orsenigo, L., 2001. The persistence of innovative activities. A cross-countries and cross-sectors comparative analysis. Research Policy 30, 1139–1158.

Chamberlain, G., 1984. Panel data, in: Handbook of Econometrics, Griliches Z, Intrilligator M (eds). North-Holland, Amsterdam. Chay KY, Hyslop DR. 2000.

Christensen, J.L. 2008. Knowledge-sourcing for food product innovation in the food and drinks industry. In Rama, R. (ed.) (2008) Handbook of innovation in the food and drink industry. New York: The Haworth Press.

Christensen, J. L., Rama, R. and Von Tunzelmann, N. 1996. Innovation in the European Food Products and Beverages Industry, European Innovation Monitoring System Publication 35, IKE Group, Aalborg University (DK).

Cohen, W. and Levin, R. 1989. Empirical studies of innovation and market structure, in: Schmalensee, R. and Willig, R. (Eds), Handbook of industrial organisation. North Holland, 1060-1107.

Cohen, W. 1995. Empirical studies of innovative activity, in: Stoneman, P. (Ed), Handbook of the Economics of Innovation and Technological Change. Blackwell, Oxford, 182–264.

Connor, J.M., 1981. Food product proliferation: a market structure analysis, American Journal of Agricultural Economics **63** (4), 607–617.

Culbertson, J. D. and Mueller, W. F. 1985. The influence of market structure in technological performance in the food-manufacturing industries. Review of Industrial Organization, 2,40-54.

De Bondt, W.F.M., 1997. The Fox Valley investors and the psychology of risk. Working paper. University of Wisconsin, Madison.

Delbono, F and Denicolo, V. 1990. *R&D* Investment in a Symetric and Homogeneaous Oligopoly : Bertrand vs Cournot. International Journal of Industrial Organization. Vol. 8, 297-313

Dosi, G., 1997. Opportunities, Incentives and the Collective Patterns of Technological Change. The Economic Journal, 1530-1547.

Duguet, E., and Monjon, S., 2002. Les fondements microéconomiques de la persistance de l'innovation. Une analyse économétrique. Revue économique vol. 53, 3, 625-636.

Feigl, S. and Menrad, K. 2008. Innovation activities in the food industry in selected European countries. Projektbericht im EU-Projekt "Traditional United Europe Food". Wissenschaftszentrum Straubing, 38

Flaig, G. and Stadler, M., 1994. Success breeds success. The dynamics of the innovation process. Empirical Economics 19(1), 55–68.

Fritsch, M. 2004: *R&D*-Cooperation and the Efficiency of Regional Innovation. Cambridge Journal of Economics, 28, 829-846.

Fritsch, M. and Franke, G. 2004. Innovation, regional knowledge spillovers and *R&D* cooperation. Research Policy, Vol.33, Issue 2, 245-255

Galizzi, G., and L. Venturini. (2008). 'Nature and determinants of product innovation in a competitive environment of changing vertical relationships'. in, Ruth Rama (ed). Handbook of innovation in the food and drink industry. New York and London: Taylor & Francis Group

García, M. and Briz, J. 2000. Innovation in the Spanish Food & Drink, International Food and Agribusiness Management Review, 3, 155–176

Geroski, P. A., Reenen, J., and Walters, C.F. 1997. How Persistently do Firms Innovate?. Research Policy 26, 33-48.

García Martínez, M. y Burns, J. (1999): "Sources of technological development in the Spanish food & drink industry: a 'suplier-dominated' industry", Agribusiness: an International Journal, vol. 15 (4), 431-448.

Goncalves, E. and Almeida, E. 2009. Innovation and Spatial Knowledge Spillovers: Evidence from Brazilian Patent Data **Source:** Regional Studies: The Journal of the Regional Studies Association, 43, 4, 513-528

González, X. and Pazó, C., 2004. Firms' *R&D* dilemma: to undertake or not to undertake *R&D*. Applied Economic Letters 11(1), 55-60.

Griffiths, W. and Webster, E. (2010). The Determinants of Research and Development and Intellectual Property Usage among Australian Companies", 1989 to 2002, Technovation*,* 30, 471–481.

Grunert, K.G., Harmsen, H., Meulenberg, M., Kuiper, E., Ottowitz, T., Declerck, F., Traill, B., and Göransson, G. 1997. A framework for analysing innovation in the food sector. In

Trail, B. & Grunert, K.G (eds.) (1997) Product and process innovation in the food industry. London; New York; Tokyo: Chapman & Hall.

Jang, S.L, and Chen, J.F. 2011. What determines how long an innovative spell will last?, Scientometrics 86, 65–76

Kleinknecht A, and Poot T.P. 1992. Do Regions Matter for R & D? Regional Studies 26(3), 221–232

Labeaga, J.M. and Martínez Ros, E. 2005. Persistence and ability in the innovation decisions. Working Papers, 2005-16, FEDEA.

López, J., and García, R., 2005. Technology and export behaviour: A resource-based view approach. International Business Review, 14 (5), 539-557.

Love, J. H. and Roper, S. 1999. The Determinants of Innovation: *R&D*, Technology Transfer and Networking Effects. Review of Industrial Organisation, 15, 43-64.

Malerba, F. and Orsenigo, L., 1999. Technological Entry, Exit and Survival: an Empirical Analysis of Patent Data. Research Policy 28, 643-660.

Malerba, F. and Orsenigo, L., 1996. Schumpeterian patterns of innovation are technology specific. Research Policy, 25, 3, 451-478
Malerba, F. 2007. Innovation and the dynamics and evolution of industries: Progress and challenges. International Journal of Industrial Organization, Vol. 25 4, 675-699.

Mantovani, A, 2006. Complementarity between product and process innovation in a monopoly setting, Economics of Innovation and New Technology, 15**,** 219–234.

Máñez Castillejo, J.A., Rochina Barrachina, E., Sanchis Llopis Z., and Sanchis Llopis, J.A., 2004. A Dynamic Approach to the Decision to Invest in *R&D*. The Role of Sunk Costs, mimeo.

Molero, J., and Buesa, M., 1998. Innovative activity in Spanish firms: regular versus occasional patterns. In: Garcı´a, C.E., Sanz-Mene´ndez, L. (Eds.), Management and Technology, 5. European Commission, Luxembourg.

Mundlak, Y., 1978. On the pooling of time series and cross section data. Econometrica 46, 69–85.

Noroha, M. T., Cesario, M. and Fernades, S. 2006. Interaction between Innovation in Small Firms and their Environments: An Exploratory Study. European Planning Studies, 14(1), 95-117.

Peters, B., 2009. Persistence of Innovation: Stylised Facts and Panel Data Evidence. Journal Technol. Transf 34, 226-243.

Porter, M. .1990. The Competitive Advantage of Nations: with A New Introduction by the Author. London: MacMillan.

Rama, R.,1996. Empirical study on sources of innovation in international food and beverage industry. Agribusiness, vol. 12(2), 123-134.

Rama, R. 1999. Innovation and profitability of global food firm. Testing for differences in the influence of the home base. Environment and Planning A, 31, 735-751.

Rama, R., and Von Tunzelmann, N. 2008. Empirical studies of innovation in the food and beverage industry. In R. Rama (Ed.), Handbook of innovation in the food and drink industry. New York/London: Haworth Press.

Raymond, W., Mohnen, P.A., Palm, F., and Schim van der Loeff, S., 2010. Persistence of innovation in Dutch manufacturing: Is it spurious?. The Review of Economics and Statistics,. 92, 3, 495-504.

Roger, M, 2004. Networks, Firm Size and innovation. Small Business Economics, Volume 22 Number 2, 141-153.

Roper, S., and Hewitt-Dundas, N., 2008. Innovation persistence: Survey and case-study evidence. Research Policy 37, 149–162.

Rosenkrantz, S., 1995. Simultaneous choice of process and product innovation. mimeo, Wissenschaftszentrum, Berlin.

Simonen, J. and McCann, P. 2008. Firm innovation: The influence of *R&D* cooperation and the geography of human capital inputs. Journal of Urban Economics, 64, 1, 146-154

Schumpeter, J. A., 1942. Capitalism, Socialism and Democracy, 3rd. Ed. Harper & Row, New York. 1962.

Segarra, A. 2009. Dinámica empresarial e innovación: la incidencia del espacio. Investigaciones Regionales, Núm. 15, 5-23

Stenberg, R. and Arndt, O. 2001. The firm or the region: what determines the innovation behaviour of European firms?. Economic Geography, 77, 364-382

Triguero A. and Córcoles, D. 2010. Understanding innovation: an analysiss of persisitence for Spanish Manufacturing Firms, Paper presented at the Twelfth annual conference of the European Trade Study Group (ETSG). Lausanne 9-11 September 2010

Von Tunzelmann, N. and Acha, V. 2005. Firms and Corporate Change in LMT Industries, in Fagerberg, J; Mowery, D and Nelson, R (Ed): The Oxford Handbook of innovation. Oxford University Press, Oxford, UK.

Wooldridge, J.M., 2005. Simple Solutions to the Initial Conditions Problem for Dynamic, Nonlinear Panel Data Models with Unobserved Heterogeneity. Journal of Applied Econometrics 20, 39-54.

Appendix

Table A.1. Descriptive statistics: dependent variables.

Variable	Definition	Number of observations (# firms)		Observations if Var=1 (# firms)		Observations if Var=0 (# firms)	
		Whole sample	*F&B*	Whole sample	*F&B*	Whole sample	*F&B*
IPROD	=1 if firm has achieved product innovations	34,831 (4,627)	5,115 (671)	8,453 (2,220)	1,133 (322)	26,378 (4,323)	3,982 (637)
IPROC	I=1 if firm has achieved process innovations	34,832 (4,627)	5,115 (671)	11,305 (2,900)	1,646 (443)	23,527 (4,225)	3,499 (588)

Source: ESEE

Table A.2. Descriptive statistics: explanatory variables.

Variable	Definition	Number of Obs. (# firms)		Average values						Standard Error	
				Total		IPROD=1		IPROC=1			
		Whole sample	*F&B*	Whole sample	*F&B*	Whole sample	*F&B*	Whole sample	*F&B*	Whole sample	*F&B*
REGIONAL SPILLOVERS	*R&D* in the same region and in the same sector corresponding to the firm i	87,951 (4,629)	12,671 (672)	0.841	0.814	0.868	0.870	0.933	0.723	2.821	3.212
LOCAL SPILLOVERS	*R&D* in different sectors and in the same region corresponding to the firm i	85,989 (4,629)	12,462 (672)	0.770	0.196	1,257	0.244	0.984	0.227	6.066	0.343
APPROPRIABILITY	Ratio of the total number of patents of the firm over the total innovators in the firm´s industrial sector	34,798 (4,627)	5,112 (671)	0.013	0.011	0.030	0.014	0.024	0.010	0.281	0.385
SIZE	Log of total employees in the firm	34,848 (4,629)	5,118 (672)	4.254	4.316	4.967	5.308	4.887	5.075	1.546	1.581
AGE	Log of the number of years since the firm was born.	74,407 (4,284)	10,735 (608)	2.854	3.032	2.996	3.187	2.953	3.156	0.928	0.931
ADVERTISING/ SALES	Percentage of advertising expenses over total sales of the firm	34,410 (4,609)	5,027 (666)	1.345	2.723	2.116	5.141	1.641	4.013	4.123	5.103
PIL	Share of employees with a long-cycle university degree on the total personnel of the company	60,067 (4,284)	8,699 (607)	4.019	3.442	5.813	4.981	5.223	4.656	7.001	5.122
PTIM	Share of employees with a short-cycle university degree on the total personnel of the company	60,067 (4,284)	8,699 (607)	5.501	4.017	7.477	5.924	6.681	5.465	8.664	6.888
PNT	Share of non-graduated employees on the total personnel of the company	60,067 (4,284)	8,699 (607)	90.477	92.541	86.697	89.096	88.086	89.881	12.671	10.130
CCLIE	Share of total final sales made to the company three main customers	33,787 (4,575)	4,971 (663)	42.786	34.539	37.805	32.058	41.997	34.935	28.774	26.576
CPROV	Share of purchases coming from the company three biggest suppliers	33,738 (4,572)	5,017 (666)	47.064	44.001	39.954	38.244	43.698	39.829	24.148	23.957

		Total Sample				IPROC=1				IPROD=1			
		Obs if Var=1		Obs if Var=0		Obs if Var=1		Obs if Var=0		Obs if Var=1		Obs if Var=0	
		Whole sample	*F&B*	Whole sample	*F&B*	Whole sample	*F&B*	Whole sample	*F&B*	Whole sample	*F&B*	Whole sample	*F&B*
R&D	*R&D*=1 if firm does or contracted *R&D* activities[6]	12,625 (36.23%)	1,487 (29.06%)	22,220 (63.77%)	3,630 (70.94%)	5,967 (70.59%)	759 (66.99%)	2,486 (29.41%)	374 (33.01%)	6,666 (58.97%)	867 (53,65%)	4,639 (41,03%)	749 (46.35%)
DMARKET1	Categorical variable which indicates the dynamism of the main market covered by the company. Categories of the variable from 1 to 3. DMARKET1=1 expansive market	9,542 (27.43%)	1,289 (25.23%)	25,240 (72.47%)	3,819 (74.77%)	2,921 (34.60%)	396 (35.04%)	5,520 (65.40%)	734 (64.96%)	3,984 (35.28%)	544 (33.71%)	7,309 (64,72%)	1,070 (66.29%)
DMARKET2	DMARKET2=1 stable market	17,197 (49.44%)	2,904 (56.85%)	17,585 (50.56%)	2,202 (43.15%)	3,600 (42.45%)	558 (49.38%)	4,841 (57.35%)	572 (50.62%)	4,983 (44.12%)	841 (52.11%)	6,310 (55.88%)	773 (47.89%)
DMARKET3	DMARKET3=1 recesive market	8,043 (23.12%)	915 (17,91%)	26,739 (76.88%)	4,193 (82,09%)	1,920 (22.75%)	176 (15.58%)	6,521 (77.25%)	954 (84.42%)	2,326 (20.60%)	229 (14.19%)	8,967 (79.40%)	1,385 (85.81%)
CM1	Categorical variable which indicates changes in the main market due to different reasons: prices changes in competition and imported products, demand changes and new competitors. CM1=1 Market changes.	24,937 (72.07%)	3,541 (69.65%)	9,665 (27.93%)	1,543 (30.35%)	5,493 (65.36%)	704 (62.52%)	2,911 (34.64%)	422 (37.48%)	7,439 (66.14%)	1,028 (63.85%)	3,809 (33.86%)	582 (36,15%)
CM2	CM2=1 No Market changes	9,665 (27.93%)	1,543 (30.35%)	24,937 (72.07%)	3,541 (69.65%)	2,911 (34.64%)	422 (37.48%)	5,493 (65.36%)	704 (65.52%)	3,809 (33.86%)	582 (36.15%)	7,439 (66.14%)	1,028 (63.855)
EXPORT	EXPORT=1 if the company exported.	20,859 (59.87%)	2,640 (51.61%)	13.981 (40.13%)	2,475 (48.39%)	6,856 (81.11%)	843 (74.40%)	1,597 (18.89%)	290 (25.60%)	8,408 (74.37%)	1,127 (69.74%)	2,897 (25.63%)	489 (30.26%)
OUTSOURCING	OUTSOURCING=1 subcontracting of production stages.	13,797 (40.92%)	1,051 (20.71%)	19,920 (50.08%)	4,025 (79,29%)	4,535 (54.88%)	400 (35.52%)	3,728 (45.12%)	726 (64.48%)	5,396 (48.78%)	478 (29.73%)	5,665 (51.22%)	1,130 (70.27%)
SHAREVO1	Categorical variable indicating the company's market-share evolution in the main market during the year t. Categories of the variable: SHAREVO1=1. It has increased	9,405 (27.21%)	1,417 (27.83%)	25,154 (72.79%)	3,675 (72.17%)	2,886 (34.34%)	406 (36.06%)	55,17 (65.66%)	720 (63.94%)	3,890 (34.58%)	575 (35.69%)	7,359 (65.42%)	1,036 (64.31%)
SHAREVO2	SHAREVO2=1. It has remained constant	19,449 (56.28%)	2,879 (56.54%)	15,110 (43.72%)	2,213 (43.46%)	4,262 (50.74%)	539 (47.87%)	4,139 (50.26%)	587 (52.13%)	5,884 (52.31%)	824 (51.15%)	5,365 (47.69%)	787 (48.85%)
SHAREVO3	SHAREVO3=1. It has decreased	5,705 (16.51%)	796 (15,63%)	28,854 (83.49%)	4,296 (84.37%)	1,253 (14.91%)	181 (16.07%)	7,150 (85.09%)	945 (83.93%)	1,475 (13.11%)	212 (13.16%)	9,774 (86.89%)	1,399 (86.84%)

Source:ESEE

6 Note that in the ESEE, the categories of the variable are: a)- It neither does nor contracts – b) It does, but it does not contract third parties c) It contracts, but it does not carry out *R&D* activities and d) It does and contracts.