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Review

Determinants of product and process innovation in small food manufacturing firms[1]

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The paper examines the determinants of product and process innovation in small food manufacturing firms. Small food manufacturing firms are generally viewed as operating in a mature and low technology area, where R&D activities are limited and patenting is rare. This research is based on an in-depth survey among 177 firms located in six rural areas in the EU. Four groups of firms are identified: non-innovators, traditionals, followers and leaders. Multiple logistic regression is developed to identify the drivers of product and process innovation in the firms. The results highlight the key role of the skills of the workforce, the firm's investment in know-how and the use of external sources of information. There is, however, no evidence of a significant relationship between the characteristics of the entrepreneur and the firm's innovation performance.

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Introduction

Until recently, innovation studies focused on radical, technology-based innovations in large firms whereas innovation patterns in small firms had widely been neglected. Over the past decade, however, an increased number of studies have explored the patterns of innovation in small firms (Romijn & Albaladejo, 2002). This tendency is closely related to the introduction of measures different from the traditional innovation indicators, such as R&D activities and patent applications (De Propris, 2000), which fail to capture the innovation capacity of small firms in general and of small firms in low tech industries in particular (Antonelli & Calderini, 1999).

Basically, it is argued that innovation in small firms is associated with entrepreneurial features and the capabilities of the workforce (Borch & Forsman, 2000; Le Bars, Mangematin, & Nesta, 1998; Romijn & Albaladejo, 2002). In addition, small firms seldom innovate in isolation but, instead, rely heavily on external sources of information and other inputs. In this context, the ability to obtain information and other inputs from outside the firm is a key determinant of innovation in small firms (De Propris, 2000; Diederen, van Meijl, & Wolters, 2002; Freel, 2000, 2004; Romijn & Albaladejo, 2002; Tether, 2002).

This paper aims to verify the extent to which the determinants of small firm innovation discussed in previous research are relevant for product and process innovation in small food and drink manufacturing firms (hereafter referred to as 'small food firms'), which are generally viewed as operating in a mature and relatively low technology area (Christensen, Rama, & von Tunzelmann, 1996; Grunert *et al*., 1997). Most of the current literature on innovation in the food industry illustrates theoretical concepts with case studies, but the empirical studies have mainly focused on large firms (Christensen *et al*.; Huiban & Bouhsina, 1998). Empirical evidence about innovation patterns in small food firms remains sparse.

Three arguments motivate the choice of analysing innovation dynamics in small food firms. First, such firms are an important sector in the overall economy. The food

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industry makes up one of the most important industries worldwide and small food firms contribute substantially to the economic performance of the industry (Traill, 1995). The food industry is one of the largest businesses in the EU, in both terms of employment and production (Christensen *et al*., 1996). The EU food industry employs more than 2.5 million people and accounts for 11% of total employment in the European industry. Moreover, the food industry has strong linkages with various other industries such as agriculture, chemicals, packaging and pharmaceuticals (Christensen *et al*.; Fanfani & Lagnevik, 1995). Second, small food firms are considered to play a potentially important role in achieving sustainable economic growth in local economies (McDonagh & Commins, 1999; Murdoch, 2000). They are particularly situated in rural areas where they have developed to process products from local agriculture (Noronha & Nicolas, 2000; Traill). Although manufacturers increasingly import raw materials from outside the region, small food firms are still typically located in rural areas and constitute an important source of employment. Moreover, small food firms tend to rely heavily on local industries and local services. Third, small firms produce specialised regional products of a different nature than those produced by large firms. Large firms generally have a national or international market approach and consequently focus on products with more of a mass appeal. In this sense, an important component of Europe's highly valued cultural identity is invested in such small companies (Committee of the Regions, 1996; Ilbery & Kneafsey, 1999; Traill).

The paper is structured as follows. In Section 2, the determinants of innovation in small firms are discussed. Section 3 develops the conceptual framework used to study the determinants of product and process innovation in small food firms and outlines the research. Section 4 presents the data analyses and discusses the results. Section 5 concludes, draws the implications of the results and formulates areas of future research.

Determinants of innovation in small firms

The innovation literature is characterised by highly diverse research methodologies, data-set features and variables selected (Montoya-Weiss & Calantone, 1994). This is one of the main reasons why authors have come to apparently contradictory results and is important to note when interpreting the outcomes of empirical studies.

A major contribution in understanding the innovation patterns in food firms has been made by Grunert *et al*. (1997) who developed a framework for analysing innovation in the food industry. Based on economics and business literature and illustrated with case studies of innovations in food firms across the EU, the authors argued that two factors drive innovation in the food industry.

The first determinant discussed in their model is research and development activities (Grunert *et al*., 1997). R&D is considered as the key factor driving technological change, which is closely linked with innovation in industrial settings. Although some authors have argued that innovation in small food firms is not primarily R&D based (Le Bars *et al*., 1998), most researches have shown that technological change is a necessary condition for innovation in such firms (Huiban & Bouhsina, 1998).

Technological change can be achieved through investment in the technological and scientific capabilities of the workforce (Leiponen, 2000). Product technology capabilities are important for successful innovation (Borch & Forsman, 2000). Diederen, van Meijl, and Wolters (2000) show that this also holds true for incremental innovation in small low-tech industries. In a survey they carried out among 1240 Dutch farms, 15% of the farmers mentioned the lack of technological skills as a reason for not innovating (Diederen *et al*., 2000).

Generally, the number of qualified scientists and engineers (QSE) is taken as an indicator of in-house technological and scientific capabilities (Huiban & Bouhsina, 1998; Leiponen, 2000). However, QSE is not unambiguously related to innovativeness in small firms. Studying small high-tech firms, Romijn and Albaladejo (2002) report that innovation is positively related to the proportion of university-trained engineers, but negatively related to the proportion of technicians. In low and medium technology firms, the use of QSE as an indicator for innovativeness are even less suitable (Freel, in press; Le Bars *et al*., 1998). In such firms, training activities in specific technology areas may better fit the needs of the individual firm (Freel, in press; Taylor, 2001).

The second determinant in the model of Grunert *et al*. (1997) is market orientation. Market orientation is defined as 'the detection and fulfilment of needs and wants of potential customers using skills, resources and competences of the company' (Grunert, Hartvig Larsen, Madsen, & Baadsgaard, 1996). An extensive market and competent management are considered key success factors for food manufacturing firms (Borch & Forsman, 2000; Earle, 1997; Grunert *et al*.). Knowledge of the market reduces the risk of product failure and enhances chances of success (Steward- Knox & Mitchell, 2003). Several case studies have illustrated that product and process innovation in the food industry, and in particular in small food firms, is often primarily the result of marketing capabilities (Le Bars *et al*., 1998). In contrast, Huiban and Bouhsina (1998) state that innovation in the food industry is still 'a technological phenomenon', whereas the role of other capabilities is limited.

Although R&D and market orientation are key drivers of the innovation process, the role of entrepreneur for innovation in small food firms cannot be ignored. The characteristics of the entrepreneur are related to background and skills and are thought to have a considerable impact on innovation. The recognition of the role of entrepreneurs in innovation dates from the seminal work of Schumpeter (1934, 1942) and has recently been re-emphasised in innovation literature (e.g. Mascitelli, 2000). The characteristics of the entrepreneur are considered to be more

important in small firms, where the entrepreneur often determines the firm's competitive strategies, as compared to larger firms which generally have 'more complex and often pluralistic decision-making structures' (Bamberger *et al.*, 1990). Several studies have explored the age of the entrepreneur as determinant for innovation in small firms. Empirical findings unequivocally indicate that young entrepreneurs are more likely to innovate as compared to older entrepreneurs (Avermaete, Viaene, & Morgan, 2002; Bamberger *et al.*, 1990; Diederen *et al.*, 2000). This phenomenon is mainly related to the strong motivation of young entrepreneurs, who have a long time horizon within the business (Diederen *et al.*, 2000). In addition, a number of studies have emphasised the importance of the entrepreneur's experience and educational background for innovation. Although there is an extensive literature devoted to the role of learning by doing and knowledge accumulated through life time experience (Mascitelli, 2000; Nightingale, 1998), there is little evidence that entrepreneurs of small firms with long working experience are more innovative than others (Romijn and Albaladejo, 2002). In the case of educational background, it has been suggested that entrepreneurs with post-school qualification are more innovative than other entrepreneurs. Schooling not only contributes to technical, communicational and social skills, but also improves the ability to learn which is crucial for innovation (Cohen & Levinthal, 1989; Leiponen, 2000). Nevertheless, current empirical studies do not show a positive relationship between the educational level of the entrepreneur and the innovativeness of small firms (Diederen *et al.*; Romijn & Albaladejo, 2002).

Apart from in-house capabilities, it is widely recognised that firms rely on external sources of information and other inputs when developing innovations. Several arguments have been raised as to why access to external resources is particularly relevant for innovation in small firms. Basically, the argument reads that small firms need external sources of information because their own resources and capabilities are limited. In this context, De Propris (2000) argued that inter-firm linkages make up the 'missing input' explaining small firm's innovation performance. Various sources of external information have been studied including formal and informal contacts with partners along the production chain as well as the reliance on services (De Propris; Diederen *et al.*, 2000; Freel, 2000; Romijn and Albaladejo, 2002; Tether, 2002). The results demonstrate that the use of external sources of information enhances innovation, but the corresponding impact depends on the sector selected and on the source of information considered. In line with the emphasis that Grunert *et al.* (1997) put on market orientation, studies have indicated that food manufacturers draw heavily on market information from customers for developing innovations (Steward-Knox & Mitchell, 2003). Further, informal contacts with similar firms tend to be particularly important for innovation (Diederen *et al.*). In sectors where product and process innovations are incremental and often have some of the characteristics of imitation, firms seem to learn from the successes and failures of their colleagues to improve their own strategy, organisation and operations (Antonelli & Calderini, 1999; Diederen *et al.*; Earle, 1997; Maskell, 2001). Co-operation with research institutes is also regarded as crucial for innovation in small low-tech firms which often lack the means and the know-how to carry out their own research activities (Baardseth, Dalen, & Tandberg, 1999).

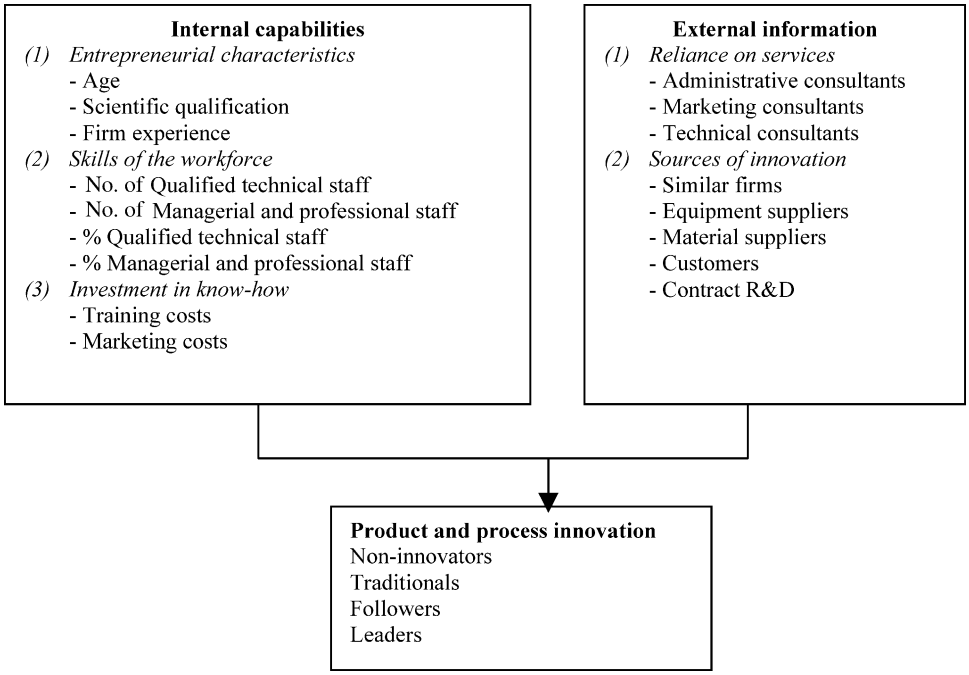

Fig. 1. Conceptual framework to analyse determinants of product and process innovation in small food firms.

Conceptual framework

Fig. 1 visualises the conceptual framework used in this research. The framework consists of a dependent variable, product and process innovation, and two explanatory factors: (1) internal capabilities, including characteristics of the entrepreneur, capabilities of the workforce as well as investment in in-house capabilities, and (2) the ability to use information from external partners. Both the in-house capabilities and the ability to use information from external partners contribute to the firm's technological capabilities and the market orientation of the firm. In this sense, the framework builds on the model of Grunert *et al*. (1997) and shows that various sources determine the innovative behaviour of the firm.

Three hypotheses are put forward. First, it is hypothesised that the characteristics of the entrepreneur are associated with the firm's innovation behaviour. A degree in science or technology and long-time experience in the firm are thought of as indicators for innovative capabilities, whereas the age of the entrepreneur is expected to be negatively associated with innovation. Second, it is argued that the skills of the workforce and the firm's investment in such skills contribute substantially to product and process innovation in small food firms. Third, it is expected that small food firms rely heavily on external sources of information when developing new products and new processes. Moreover, collaboration with external partners is considered to be an important factor for innovation in small food firms.

Two indicators are applied to measure product and process innovation. First, in the fieldwork survey described below, the interviewees were asked if they carried out R&D activities over the past five years. If the answer to this question was positive, respondents were requested to indicate the percentage of their annual turnover that is spent on R&D activities. Traditionally, R&D activities are considered to be the main factor in technological development and are one of the most commonly used indicators for innovativeness. Although R&D statistics often represent a good proxy for innovativeness (Antonelli & Calderini, 1999; Romijn and Albaladejo, 2002), they measure the firm's innovation input rather than the firm's actual innovativeness (Godin, 2002). Therefore, the second question directly addresses the firm's innovation activities. Respondents to the survey were requested to indicate whether they introduced substantially modified product or processes over the past five years. This indicator relies on the subjective judgement of the interviewees, though it has previously been found to perform consistently well in analyses (Huiban & Bouhsina, 1998; Morgan, Crawford, & Avermaete, 2003; Romijn & Albaladejo, 2002).

Based on the information that was collected on the firms' innovativeness, four groups are distinguished: non-innovators, traditionals, followers and leaders. The classification provides information on the firm's intensity of product and process innovation as a whole. Non-innovators include those firms that have not introduced new or substantially modified products or processes. Traditionals are firms that introduced product or process innovations, but had no R&D activities. Followers and leaders are firms in which product or process innovation is introduced and in which the firm has invested in R&D activities. Followers spent at most 1% of their annual turnover on R&D whereas in leaders, these expenditures exceeded 1% of the annual turnover.

Based on theory and previous empirical studies, 17 independent variables are selected: nine variables on internal capabilities and eight variables on external information. The variables are either continuous or dummies. The five variables on the external sources of product and process innovation are only relevant for firms that introduced product or process innovation. A description of the independent variables is provided in Appendix A.

In order to verify the conceptual framework, a survey was conducted among small food firms in the EU. The data set examined is the response of food manufacturers to a survey within the framework of the European Innovaloc project. Data were collected in six European regions: Devon and Cornwall as well as Hereford and Worcester in the UK, Hainault and West Flanders in Belgium and, Northwest Border and South West in the Republic of Ireland (Noronha, Cesario, & Avermaete, 2001).

The target population included small food manufacturing firms with between 3 and 50 employees. Bakeries were excluded from the sample to avoid the inclusion of small retail shops. Based on information from national institutes of statistics, regional and local authorities and commercial bodies, 691 firms were identified to fulfil the conditions of the research. Quota sampling was used to select the firms with the aim of studying 30 firms in each region. In the UK, there was a high response rate with only five firms refusing to co-operate. In the Irish and Belgian regions, in contrast, several firms declined to participate in the survey, mainly because of time pressures. The final response rate includes 177 small food firms, representing more than one-fourth of the target population. A pilot survey was carried out in May 2001 and the final survey was held from July to December 2001. It was based on in-depth face-to-face interviews with the top manager or owner of the firm. Each interview lasted between one and one and a half-hour.

Results

Evidence of innovation in small food firms

About 80% of the firms introduced at least one type of product or process innovation over the past five years. The results illustrate the frequency of product and process innovation in small food firms. Cross-tabulation is developed to verify the co-incidence of product and process innovation. Of the 148 innovative firms, 100 firms introduced both product and process innovation, whereas 10 firms introduced only process innovation and 38 firms introduced only product innovation. Chi square statistics confirm the relationship

Table 1. Innovation groups ($N=177$)

	Number of firms	Percentage of firms	R&D expenditures as % of turnover
Non-innovators	29	16.4	0.17
Traditionals	38	21.5	0.00
Followers	78	44.1	0.50
Leaders	32	18.1	6.53
Total	177	100	1.43

between product and process innovation in small food firms ($\chi^2=28.338$, $p=0.000$).

The number of firms in each of the four innovation groups is provided in Table 1. Most of the firms in the sample are followers, having R&D expenditures that represented 1% or less of the firm's annual turnover. In 37 followers, the R&D expenditures was an insignificant share of the annual turnover. In 32 innovative firms, the R&D expenditures exceeded 1% of the annual turnover. A considerable amount of firms introduced product or process innovations without carrying out any kind of R&D activity. These include, for example, firms that introduced a regionally labelled product in the framework of a regional development program such as LEADER, which supports innovation projects undertaken by local action groups.

The sample firms only spent a very small proportion of their budget on R&D activities. From the 29 non-innovators, 13 firms claim they had R&D activities, though no figures above 1% are found among these firms. The average R&D expenditure of all firms in the sample is 1.43% of the annual turnover, this figure is 1.68 if only innovative firms are taken into account.

The findings support the idea that small R&D efforts make the difference for product and process innovation in small food firms. As Gallizi and Venturini (1996) formulated: "(…) even a low R&D intensity is sufficient to determine a relevant flow of new product introduction in an industry where innovation is incremental and technological opportunity is redundant". This tendency is also reflected in the results of a survey among 2783 French agro-food firms in which almost 70% of the firms claimed to have achieved at least one innovation while research expenditures represented less than 1.7% of their value added (Le Bars *et al*., 1998).

Modelling patterns of innovation in small food firms

In order to identify the determinants of product and process innovation in small food firms, multinomial logistic models are applied using SPSS NOMREG. The method allows the extent to which the selected determinants are associated with different types of innovation behaviour to be identified. The analyses are carried out in two phases. In a first phase, non-innovators are compared with the different groups of innovating firms. In a second phase, the three groups of innovators are compared to verify the characteristics that determine the type of innovation behaviour.

Table 2 provides the descriptive statistics of the independent variables. Correlation tests on the independent variables, which are required for multinomial logistic regression, indicate no multicollinearity among the selected variables. The questions on external sources of innovation are only relevant for firms that introduced an innovation, i.e. traditionals, followers and leaders.

Some general conclusions on small food firms can be derived from the descriptive statistics. Managers of small food firms tend to be relatively old and have, on the average, about 13 years experience in the firm. Less than half of the firms are run by a manager that has a degree in science or technology. The firms include only few qualified staff of which managerial and professional staff is generally better represented than qualified technical staff. Training costs are limited, with an average expenditure that is below 1% of

Table 2. Descriptive statistics (means and proportions)

	Non-innovators	Traditionals	Followers	Leaders	Average
Age	4.41	4.18	4.14	3.94	4.16
Scientific qualification (%)	38	24	42	38	37
Firm experience	15.34	12.47	14.88	8.91	13.36
No. of qualified technical staff	0.52	0.39	1.25	1.75	1.03
No. of managerial and prof. staff	2.21	2.68	3.38	3.81	3.11
Qualified technical staff (%)	2.40	1.78	8.30	9.42	6.11
Managerial and prof. staff (%)	28.70	21.78	19.68	24.70	22.55
Training costs	0.37	0.51	0.91	1.63	0.86
Marketing costs	0.76	4.47	3.49	6.53	3.81
Administrative consultants (%)	83	84	85	97	86
Marketing consultants (%)	55	42	53	63	53
Technical consultants (%)	34	32	46	66	45
Similar firms (%)	–	13	26	28	23[a]
Equipment suppliers (%)	–	34	44	41	41[a]
Material suppliers (%)	–	8	12	13	11[a]
Customers (%)	–	26	54	53	47[a]
Contract R&D (%)	–	5	17	44	20[a]
N	29	38	78	32	177

[a] $N=148$ (non-innovators were excluded for the calculation).

the annual turnover. Several entrepreneurs claimed that public authorities supported their training programs, particularly when such programs dealt with food safety and hygiene. Marketing expenditures are also low, with an average below 5% of the annual turnover. Focusing on external sources of information, the firms rely heavily on administrative consultants and—although to a lesser extent—on marketing and technical consultants. Customers and suppliers of equipment are most frequently mentioned as sources of product and process innovation. Finally, the statistics show large differences across the four innovation groups. These statistics will be referred to when interpreting the results of the logistic models.

Table 3 details the results of the multinomial logistic model comparing non-innovators with traditionals, followers and leaders. For this purpose, the dependent variable is coded zero if leader, one if follower, two if traditional and three if non-innovator. As the questions on sources of product and process innovation are not relevant for non-innovators, the corresponding variables on this item are excluded from the model.

The role of the manager's background and experience is not significant. In contrast with previous findings (Diederen *et al*., 2000), the age of the entrepreneur does not statistically differ between non-innovators and innovators. At this stage, it should be noted that significant differences might have been obtained if absolute figures on the entrepreneur's had been available.

The difference between non-innovators and innovators on the basis of the skills of the workforce is very clear; firms with a higher number of managerial and professional staff are more likely to innovate. This holds true for the comparison of non-innovators (2.21) with all three categories of innovators: traditionals, followers and leaders (respectively, 2.68, 3.38 and 3.81). The proportion of managerial and professional staff in the firm, in contrast, tends to be negatively associated with innovation. About 29% of the workforce in non-innovators is classified as managerial or professional staff, this figure is significantly lower in traditionals, followers and leaders (respectively, 21.78, 19.68 and 24.70). The results suggest that a large proportion of managerial and professional staff reduces the flexibility and the efficiency of the firm. Both flexibility and efficiency are key components of competitiveness in small food firms, where innovation is often a matter of responding fast to market opportunities (Grunert *et al*., 1997).

The results further indicate that the number and the proportion of qualified technical staff discriminate between followers and leaders on the one hand and non-innovators on the other hand. Followers and leaders have a significantly higher number of qualified technical staff relative to non-innovators (1.25 and 1.75 compared to 0.52). Also the proportion of qualified technical staff is significantly lower for non-innovators (2.40%) as compared to followers and leaders (8.30 and 9.42%). The results suggest that in-house technical capabilities support innovation in a low technology industry. In other words, the results confirm that a lack of technical capabilities may constitute a hinderance to innovation by small firms (Diederen *et al*., 2000).

Focusing on investments in know-how, it becomes clear that efforts to train the workforce and marketing activities are both associated with innovation. Training expenditures are significantly higher in followers and leaders as compared to non-innovators. In non-innovative firms, training activities are generally limited to the food safety and hygiene programs which are organised by public authorities and essential for most small food firms to keep up with regulatory standards (Taylor, 2001). Although such programs are relevant for most of the firms in the sample, several followers and leaders are also involved in technology training and training in IT. Apart from very low training expenditures, non-innovators have very low marketing costs with an average below 1% of the firm's annual turnover. This is significantly lower than

Table 3. Multinomial logistic model comparing non-innovators with traditionals, followers and leaders

	Non-innovators vs. traditionals	Non-innovators vs. followers	Non-innovators vs. leaders
Intercept	−0.228 (0.023)	1.039 (0.591)	1.161 (0.010)
Age	−0.256 (0.589)	−0.500 (2.421)	−0.470 (1.663)
Scientific qualification	1.051 (2.684)	0.082 (0.021)	0.402 (0.351)
Firm experience	−0.052 (2.252)	0.016 (0.333)	−0.063 (2.312)
No. of qualified technical staff	−0.589 (1.113)	−0.901 (4.342)**	−0.782 (3.090)*
No. of managerial and prof. staff	0.474 (5.393)**	0.682 (10.666)***	0.736 (11.078)***
Qualified technical staff (%)	1.237 (0.014)	17.337 (4.972)**	15.008 (3.529)*
Managerial and prof. staff (%)	−3.489 (4.146)**	−7.752 (11.260)***	−5.118 (5.205)**
Training costs	−0.185 (0.129)	0.853 (3.360)*	0.862 (3.321)*
Marketing costs	0.408 (4.828)**	0.341 (3.397)*	0.385 (4.294)**
Administrative consultants	0.026 (0.001)	0.019 (0.001)	−1.270 (0.979)
Marketing consultants	1.345 (4.956)**	0.877 (2.456)	0.784 (1.372)
Technical consultants	0.422 (0.404)	0.020 (0.001)	−0.303 (0.188)
Nagelkerke R^2	0.488		
−2 Log-likelihood	333.585***		
χ^2 (36 df)	99.096		
N	164		

Figures in parentheses are Wald statistics. *** Significant at 1%, ** significant at 5%, * significant at 10%.

the marketing costs in traditionals, followers and leaders (respectively, 4.47, 3.49 and 6.53).

Finally, differences in reliance on services are derived. Traditionals are less likely to rely on marketing consultants as compared to non-innovators (42% compared to 55%). Although not significant, the descriptive statistics in Table 3 show that leaders are considerably more likely to consult technical experts as compared to non-innovators.

Table 4 details the results of the multinomial logistic model comparing leaders, followers and traditionals. For this purpose, non-innovators are not included in the analysis and the variables on external sources of innovation are added to the model. In order to provide statistics on all possible comparisons, the coding of the dependent variable is reversed.

Groups of innovative firms differ in both age and firm experience. Entrepreneurs in low technology firms are significantly younger than entrepreneurs in traditional firms. Managers of leaders have generally less experience in the business as compared to followers. Managers of followers have less experience in the business as compared to traditionals. The descriptive statistics also indicated that 38% of the leaders are run by managers that have a degree in science or technology as compared to 24% in the case of traditionals. Nevertheless, this difference is not significant.

The skills of the workforce cannot be used to differentiate between leaders on the one hand, and followers and traditionals on the other hand. As would be expected, followers and leaders have a considerably higher proportion of technical staff as compared to traditionals. With respect to investment in know-how, leaders and followers spend a significantly higher proportion of their annual turnover on training activities than traditionals (1.63 and 0.91% compared to 0.51%). Similar to non-innovators, traditionals participate in the public programs of food safety and hygiene training though seldom invest in technical training and training in IT.

In general, leaders rely more on services and are more likely to use external sources of innovation as compared to followers and traditionals. Leaders rely significantly more on consultants for legal work and accountancy than traditionals (97% compared to 84%). Leaders and followers are also more likely to use information from consumers when introducing new products or new processes as compared to traditionals (53 and 54% compared to 26%). Investing in R&D activities, followers and leaders may try to reduce the risks of innovation by co-operating and observing potential consumers. Finally, and most striking, is the importance of research institutes as a source of innovation. About 44% of the leaders consult one or more research institutes when developing product or process innovation. In the case of traditionals and followers, this figure is significantly lower (respectively, 5 and 17%). Also, followers collaborate more with research institutes as compared to traditionals. The results suggest that if small food firms want to invest in R&D activities, they need to collaborate with external partners because of the lack of internal expertise and the limited means to carry out in-house R&D activities.

Conclusions

The objective of this paper was to identify important determinants of product and process innovation in small food firms. The paper used data from a survey carried out among 177 such firms in the EU. Rather than seeking for new factors

Table 4. Multinomial logistic model comparing traditionals, followers and leaders

	Leaders vs. traditionals	Leaders vs. followers	Followers vs. traditionals
Intercept	−8.009 (7.232)***	−0.436 (0.057)	7.574 (8.458)***
Age	0.479 (1.627)	−0.067 (0.055)	−0.545 (3.207)*
Scientific qualification	0.607 (0.683)	−0.231 (0.174)	−0.839 (1.894)
Manager experience	0.016 (0.135)	0.077 (5.062)**	0.062 (3.813)*
No. of qualified technical staff	0.168 (0.117)	−0.020 (0.010)	−0.189 (0.153)
No. of managerial and prof. staff	−0.126 (0.459)	−0.057 (0.143)	0.069 (0.168)
Qualified technical staff (%)	−9.802 (1.319)	1.637 (0.189)	11.440 (1.881)
Managerial and prof. staff (%)	−0.007 (0.000)	−2.836 (1.417)	−2.830 (1.304)
Training costs	−0.756 (3.173)*	−0.007 (0.003)	0.749 (3.257)*
Marketing costs	0.017 (0.243)	−0.030 (0.560)	−0.047 (1.305)
Administrative consultants	2.544 (3.483)*	1.353 (1.238)	−1.191 (1.961)
Marketing consultants	0.941 (1.470)	0.378 (0.429)	−0.563 (0.764)
Technical consultants	1.074 (2.078)	0.538 (0.953)	−0.536 (0.744)
Similar firms	1.221 (1.945)	0.408 (0.411)	−0.813 (1.221)
Equipment suppliers	−0.470 (0.436)	−0.185 (0.109)	0.285 (0.236)
Material suppliers	0.559 (0.255)	−0.525 (0.426)	−1.124 (1.247)
Customers	2.635 (9.592)***	0.489 (0.703)	−2.146 (9.090)***
Contract R&D	3.404 (9.679)***	1.646 (6.538)**	−1.758 (2.939)*
Nagelkerke R^2	0.523		
−2 Log-likelihood	197.206		
χ^2 (34 df)	82.444***		
N	135		

Figures in parentheses are Wald statistics. *** Significant at 1%, ** significant at 5%, * significant at 10%.

driving these types of innovation, the research verified the extent to which the currently recognised determinants of innovation are relevant for small food firms.

Four groups of firms were identified: non-innovators, traditionals, followers and leaders. The last three categories include the innovative firms and differ in terms of R&D activities. Traditionals have no R&D activities, followers have limited R&D activities and leaders have the most intensive R&D activities. The research confirms the evidence of product and process innovation in small food firms. Most of the firms in the sample could be classified as innovative, whereas only a minority of the firms did not innovate at all over the past five years. The descriptive statistics indicate that R&D activities in small food firms are mainly small scale. In this sense, the results confirm that R&D expenditures fail to measure innovation in the food industry in cross-sectoral studies (Antonelli & Calderini, 1999).

The first hypothesis of the research, namely that innovation was related to the manager's background and experience, could not be confirmed. The characteristics of the top managers did not discriminate between non-innovators and innovators. However, they were linked to the type of innovation. In this context, the results showed that the top managers in traditional firms were on the average older and had less years of experience as compared to those in the followers.

The second hypothesis dealt with the role of the workforce's skills and the investment in such skills for innovation. The data supported the hypothesis that non-innovators were differentiated from innovators on the base of the skills of the workforce. In contrast with the results obtained by Freel (2004), the results suggest that innovative firms have a higher number and a higher proportion of qualified technical staff. Both tendencies were significant as regards the comparison of non-innovative firms with followers and leaders. Similarly, the number of managerial and professional staff was positively and significantly related to innovation. This trend did not hold true for the proportion of managerial and professional staff, where significantly higher scores were found for non-innovators as compared to innovators. Investment in know-how, measured through training expenditures and marketing costs, was positively and significantly related to innovativeness. Although the skills of the workforce and the investment in know-how tended to determine whether firms would innovate, these characteristics did not explain why some firms were traditionals, followers or leaders.

The third hypothesis stated that inter-firm linkages are an important factor for innovation in small food firms. Data on the firms' use of services did not support the view that innovative firms relied more heavily on external partners as compared to non-innovative firms. Nevertheless, inter-firm linkages differentiated between the groups of innovative firms. Concentrating on the innovative firms in the sample, the results indicated that the higher the firm's R&D efforts, the more intensive the firm's collaboration with customers and research institutes.

The paper raises important policy implications. Over the last decade, governments have regarded innovation in small food firms as an efficient instrument to decrease the striking disparities in economic performance between European regions, particularly between central and peripheral areas. Policy makers have therefore put some emphasis on

Table A1. Determinants of product and process innovation in small food firms

Variable	Definition
Internal capabilities	
Characteristics of the entrepreneur	
Age	Age of the entrepreneur (2 = 20–29 years, 3 = 30–39 year, etc.)
Science qualification	Dummy: 1, entrepreneur has a degree in science or technology (including engineering); 0, otherwise
Firm experience	Number of years the entrepreneur has worked in the firm, either as top manager or otherwise
Skills of the workforce	
No. of qualified technical staff	Number of qualified technical staff
No. of managerial and prof. staff	Number of management and professional staff
Qualified technical staff (%)	Proportion of qualified technical staff in the total workforce
Managerial and prof. staff (%)	Proportion of management and professional staff in the total workforce
Investment in know-how	
Training costs	Expenditures on training activities in 2000, as % of the firm's turnover
Marketing costs	Expenditures on marketing activities in 2000 as % of the firm's turnover
External information	
Reliance on services (over the past five years)	
Administrative consultants	Dummy: 1, relied on consultants for legal work and accountancy; 0, otherwise
Marketing consultants	Dummy: 1, relied on marketing consultants (including advertising); 0, otherwise
Technical consultants	Dummy: 1, relied on technical consultants; 0, otherwise
Sources of product and process innovation (carried out over the past five years)	
Similar firms	Dummy: 1, similar firms composed a source of innovation; 0, otherwise
Equipment suppliers	Dummy: 1, suppliers of equipment composed a source of innovation; 0, otherwise
Material suppliers	Dummy: 1, suppliers of material composed a source of innovation, 0, otherwise
Customers	Dummy: 1, customers composed a source of innovation; 0, otherwise
Contract R&D	Dummy: 1, research institutes (incl. research institutes, universities, technology partners, licensors and licensees) composed a source of innovation; 0, otherwise

enhancing R&D activities in small food firms that are located in rural areas. However, the results indicate that several non-innovative firms invest in R&D, whereas there are a considerable amount of innovative firms that have no R&D activities. Policy makers should consider which firms they want to reach when designing policies. If the aim is to increase innovation among small food firms, this research concludes that more weight should be put on improving the in-house capabilities of the workforce rather than focusing on R&D activities.

The study opens the field for further research in the domain of innovation in small food firms. A key question that arises from this research concerns the profitability of R&D based innovation compared to innovations that are not R&D based. Closely related to this research question, it would also be interesting to get deeper insights into the R&D activities of small food firms, focusing in particular on who is involved in such activities at the firm level and the nature of co-operation with research institutes. This knowledge would also be useful for policy makers to better respond to the needs of small food firms.

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Appendix A

Table A1

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