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External Knowledge Sources as Drivers for Cross-Industry Innovation in the Italian Food Sector: Does Company Size Matter?

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Abstract

Knowledge and competencies traditionally rooted in industries external to the food sector's boundaries are gaining momentum and foster innovation in the food domain. In Italy, food companies collaborate with other firms in open and cross-industry innovation (CII) projects to achieve a competitive advantage. The paper aims to shed lights on eventual drivers for CII in the food sector in a twofold manner: (i) exploring to what extent external knowledge sourcing affects innovation and (ii) seeking to understand to what extent different means of external knowledge sourcing might differ according to the company size. To this end, probit models have been run on a sample of 703 Italian food companies from the CIS 2010 and 2012. Empirical evidence shows that in the Italian food industry innovation relies on different external knowledge sources. Acquisition of machinery and equipment allows food companies to transfer external know-how inside the firm boundaries. Product innovation benefits of external R&D activities as well as of information provided by competitors and consultants. Process innovation relies mostly on acquisition of technology (machinery and equipment) as well as on information provided by input suppliers.

Keywords: SMEs, CIS, food industry, innovation type, cross-industry, Italy

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Introduction

Small and Medium-sized enterprises (SMEs) build the backbone of the European food sector, with a turnover of 528 billion € (49.6% of European food turnover) and 2.9 million employees (63.3% of European food employment) (FoodDrinkEurope 2015). Despite its strength and robustness, the food sector is currently facing several opportunities and threats that affect the competitive performance of firms (Carraresi and Banterle, 2015), like, for example, decreasing transportation costs, trade flow liberalization and increasing raw material price volatility (European Commission 2009). Moreover, as a recent study of Nestlé[1] illustrates, there is a growing share of consumers, which seek health-promoting or more sustainable foods which allow for market growth and successful product differentiation, hence, above average returns. Nevertheless, new food technologies, like Pulsed-Electric fields or High Pressure Processing, allow for safer and more efficient food production, which requires larger up-front investments SMEs most likely cannot afford. Indeed, food SMEs have both a lower market and bargaining power than large companies, respectively in horizontal and in vertical markets (European Commission 2009). Solutions to increase SME competitiveness may include major investments into their innovation activity, which is essential for their whole business performance (Tepic et al. 2014). Nonetheless, SMEs often lack resources and qualified personnel for R&D and are usually relatively traditional with limited capabilities for exploring new technologies and areas of consumption (Banterle et al. 2011; Dries et al. 2014). These elements constitute barriers that hamper food SMEs from innovating and being competitive.

However, a means to foster their innovation capacity and to shorten the time to market is to collaborate with other companies through an "open innovation" approach based on knowledge and resource sharing (Chesbrough 2006; Dahlander and Gann 2010; Tepic et al. 2014). Indeed, according to market changes, innovation is currently shifting from closed firm-level patterns to collaborative and open-mode ones (Granieri and Renda 2012). For example, the level of interaction of different members of the supply chain is increasing by making use of an integrated model of innovation based on cooperation along the chain to overcome knowledge and competence gaps during the innovation process (Menrad 2004; Lew and Sinkovics 2013).

Moreover, beyond chain collaboration, knowledge, competencies and entire technology platforms traditionally rooted in industries external to the food sector's boundaries are increasingly becoming important and foster innovation in the food domain. Thus, **cross-industry innovation** (CII), defined as "the application of established knowledge or technologies of partners from outside a firm's own value chain" which "provides a specific inter-organizational setting in which to pursue exploratory innovation" (Enkel and Heil 2014, 243), can be observed in different convergence settings where the food industry is involved in, e.g. nutraceuticals at the border of foods and drugs (Bröring 2010) or with the bioenergy sector (Golembiewski et al. 2015). Consequently, in order to create innovative technological solutions, food companies seem to increasingly depend on knowledge coming from outside their own domain (Malerba 2002; Eckhardt and Shane 2003; Robertson and Patel 2007; Di Stefano et al. 2012; Costa et al. 2015; Dingler and Enkel 2016). However, since innovation patterns and technological change make sectors different according to the essence of the dominant technology, innovation paths result to

[1] http://www.nestle.de/zukunftsstudie

be very sector-specific (Malerba 2004). Thus, a firm able to combine its internal know-how with external knowledge (Kogut and Zander 1992) traditionally belonging to different sectors (Bierly and Chakrabarti 1999) is more encouraged to implement innovation. That explains why the notion of CII is getting momentum in both academia and industry. CII represents a way through which firms can acquire external knowledge in their own organization impacting positively on their innovation activity (Cohen and Levinthal 1990; Enkel and Gassmann 2010; Lew and Sinkovics 2013; Enkel and Bader 2015; Dingler and Enkel 2016). Furthermore, this activity can benefit from resource complementarity of the different sectors involved (Lew and Sinkovics 2013). That is, the more the sectors are different in terms of resources and competencies the more they are pushed to interact with each other and to bring together different knowledge areas, in order to enhance the opportunities for innovation (Gassman and Zeschy 2008; Enkel and Gassmann 2010; Enkel and Bader 2015). Resource complementarity is a relevant issue also in fostering collaboration processes between small and large companies when it comes to pursuit innovation (Harrison et al. 2001; King et al. 2003). Finally, "complementary resources between firms will often motivate vertical alliances, where firm operations emphasize different stages of the value chain and, as such, exhibit resource profile differences" (King et al. 2003, 597).

Study Domain and Research Questions

Given this background, the capability of firms to acquire and internalize external knowledge can build the basis for engaging in CII; namely, innovation might be affected by collaboration and information stemming from other industries. The increasing importance of knowledge coming from outside the own sector gets also confirmed by Capitanio et al. (2010) who states that this holds true for Italy as well. Here, innovation is considered as strategic for the companies to face growing competition from emerging countries and the large market penetration potential from other developed countries. Furthermore, the Italian food industry is also increasingly depending on new technologies developed outside the food industry (Capitanio et al. 2009 and 2010). Indeed, even though engaging in a systematic literature review is not in the focus of the paper, we have tried a rough publication research within Web of Science in order to filter the results dealing with CII in the food domain. The database gave us back only one article where cross-industry is seen as an area of development of an adaptive extension platform for the Australian and New Zealand dairy sectors (Murphy et al. 2013). This does not mean that the topic is not debated in the scientific literature, but rather that it still does not exist as an acknowledged empirical framework of CII applied to the food industry. Articles analyzing this issue in the food sector are using several terms to define innovation across different industries, but rarely they refer to CII.

Moreover, the Italian food industry, likewise the entire EU sector, is also dominated by SMEs, which can collaborate (rather than compete) with other firms in open and CII projects by sharing capabilities and knowledge, leading to potential growth (Fukugawa 2006; van de Vrande et al. 2009). Nevertheless, despite their huge contribution to the food industry, SMEs have received much less attention in the academic innovation management literature than large companies (Saguy and Sirotinskaya 2014).

Against this backdrop, the paper seeks to contribute to the notion of CII in the food sector in a twofold manner. First, we explore to what extent external knowledge sourcing, which builds the basis for engaging in CII, affects innovation. This motivates:

Research Question 1–*What is the impact of different means of external knowledge sourcing (building the basis for CII) on product and process innovation?*

Second, this paper seeks to understand to what extent different means of external knowledge sourcing might differ according to the company size. Indeed, small and large firms are recognized as being different in their innovation behavior, especially due to the pivotal role of technological innovation to achieve a competitive advantage in many sectors (Hamilton 1985) and to the consequent need for companies to somehow face their differences in resource endowments and capabilities (King et al. 2003). Diversity among company sizes concerning innovation has been highlighted by several authors in the past (King et al. 2003). Both small and large firms can have an advantage in innovation, but it has different sources: normally, small firms can generate outstanding inventions and product innovations (but often are limited in resources to exploit them), whereas large companies are better in processing, demonstrating that both can complement each other to enhance innovation (King et al. 2003). The resource complementarity leads to cooperation as both small and large companies perceive it and try to cooperate in order to acquire the missing knowledge. This phenomenon has been explored in the past by Acs and Audretsch (1988) and is also part of the acknowledged theoretical approach of "relational view" (Dyer and Singh 1998). Nevertheless, almost no studies in the literature investigate what is happening in the food sector, concerning the effect of knowledge sourcing on innovation and its role in promoting CII. Thus, here, we are interested to elucidate the particularities of SMEs vs. large enterprises in the food sector, which lead us to:

Research Question 2–*Do means of external knowledge sourcing (the basis for CII) differently affect innovation according to company size?*

To answer these questions, Italy has been taken as a case study, as the structural organization of its food industry reflects the European one, with a preponderance of SMEs (ISTAT 2011). Company data coming from the Community Innovation Survey (CIS) 2010 and 2012 are used to carry out a firm size comparison relatively to different external knowledge sourcing and innovation.

The remainder of the paper is organized as follows: in the next section, we provide a conceptual framework on external knowledge sourcing, supported by the literature review, which helps the reader to understand its relationship with innovation and its role as a probable precursor for CII. Then, in the methodology, we provide an exhaustive explanation concerning the data, the variables, their measures, and the model used. The estimation of the model leads us to the results of the paper which are presented and discussed according to the research questions and contrasted with previous literature. These results are summarized in the conclusions, also providing useful managerial implications.

Conceptual Framework

According to our introductory background and study domain, we assume that different means of external knowledge sourcing might be precursors of CII, namely build the basis for collaboration among companies in different sectors aimed at innovation (Dingler and Enkel 2016). Indeed, CII seems to depend on the level of knowledge heterogeneity among firms belonging to different industries, also called "cognitive distance" (Nooteboom 1999; Nooteboom et al. 2007; Enkel and Heil 2014). Therefore, the more the companies are putting efforts into acquiring external knowledge to create innovation, the more they are likely to end in CII processes. To this scope, some variables from the CIS 2010 are useful to investigate the relationship with innovation and can be considered the drivers for CII. The variables that have been chosen for this purpose concern external R&D, the acquisition of machinery and equipment, cooperation, new methods of organising external relations (e.g. alliances, partnerships, etc.), the acquisition of external knowledge (e.g. patents, know-how, etc.), the search of general information from suppliers, consultants and competitors.

External R&D

External R&D is defined as the engagement of the company in creative work performed by other firms and/or public or private research organizations. External R&D is profitable for product and process innovation. Indeed, a previous study underlines that R&D is "a necessary complement to openness for ideas and resources from external actors" (Dahlander and Gann 2010, p. 701). Also, external R&D is helpful when the internal R&D department has limited resources that can be in this way complemented (Chesbrough 2003). Likewise, R&D needs cooperation agreements enabling firms to merge external R&D with the existing one (Sagarra-Blasco and Arauzo-Carod 2008), and to share and/or acquire new knowledge (Veugelers and Cassiman 2005; Ruben et al. 2006).

Acquisition of Machinery and Equipment

This variable defines the engagement of the company in "acquisition of advanced machinery, equipment or software to produce new or significantly improved products and processes" (tab. A). When it comes to realizing innovations across sector boundaries, the acquisition of technology is unavoidable, especially in technology-push processes. To this end, it is necessary for the companies to exit the borders of their sector to purchase equipment and machinery that are aimed at improving the implementation of innovation and the overall competitiveness (Lee et al. 2010).

Cooperation

Cooperation includes active participation among companies or institutions on innovation activities. It may be intended as a way to get external knowledge into the company (Bröring and Herzog 2008). Cooperation affects innovation activities as it allows to exploit the resource complementarity, especially between small and large firms, even belonging to different sectors. Indeed, while small firms are more inclined than large ones to follow technological discontinuities and approach even uncertain markets, large companies possess the needed capabilities to put a new idea into practice (King et al. 2003). Therefore, small firms are usually more facilitated in getting external technology (e.g. from government organizations, universities, research institutes), but they need large firms in order to exploit this external R&D (Freeman and Soete 1997; King et al. 2003). That is why cooperation represents a direct consequence and is almost unavoidable when it comes to CII.

Acquisition of External Knowledge

The increased need for customized products gearing the demand for innovation leads firms to acquire external knowledge from related industries (Bröring and Herzog 2008). The acquisition of external knowledge encompasses the purchase or licensing of inventions (patented or not), know-how, and other types of knowledge from other companies or organizations. Actually, previous scholars already pointed up the importance of external knowledge as a resource for innovation, as it does not decrease when is shared (Freeman 1991; Antikainen et al. 2010). Indeed, the majority of innovations are realized when companies cross the boundaries of different knowledge domains (Leonard-Barton 1995; Carlile 2004; Antikainen et al. 2010).

New Methods of Organizing External Relations

Whenever a company engages in acquiring knowledge from outside its boundaries, there is a consequent need to adapt its organizational procedures accordingly. These procedures are represented by alliances, partnerships, outsourcing or sub-contracting, and other practices that companies have to manage for the acquisition of external knowledge and/or technology. As Schumpeter (1934) already asserted, the introduction of innovation always requires a firm to change in managerial practices. Furthermore, there is also evidence that organizational procedures can increase product and process innovation and lead to a superior performance (Schmidt and Rammer 2007; Mol and Birkinshaw 2009; Doran 2012). In particular, alliances arise when there is resource complementarity among companies (King et al. 2003), and this is often verified in the case of CII, and also they allow a higher control and access over the external resources the firm is acquiring (Haspeslagh and Jemison 1991; Das and Teng 1998).

External Information from Suppliers, Competitors, Consultants

Getting information from suppliers, competitors, and consultants – even stemming from other industries - allows companies to generate new ideas and innovations by merging this information with their internal know-how. (Rosenkopf and Nerkar 2001; Katila 2002; Lefebvre et al. 2015). Indeed, diverse information sources (from suppliers, competitors, consultants) are complementary and, if merged with the existing knowledge, allow to create new knowledge useful for innovation (Tether and Tajar 2008; Lee et al. 2010). Therefore, companies should always look for external information which can then be embodied into innovation (Köhler et al. 2012; Costa et al. 2015). Through the acquisition of external information, companies demonstrate an open-minded behavior, being increasingly able to scan the market and identify those opportunities which allow them to be more efficient in implementing innovation and decrease the risk of product failure (Stewart-Knox and Mitchell 2003; Avermaete et al. 2004; Wei and Wang 2011).

Methodology

The need to collect a comprehensive set of data on the multi-faceted nature of innovation activities has led to the widespread use of firm-level innovation surveys. The dataset used in the paper is based on the two Community Innovation Surveys (CIS) carried out in Italy in 2010 and 2012, referred to innovation activities undertaken during the period 2008–2012. The CIS is a biennial national data collection survey based on the OECD's Oslo manual to gather information on the extent of innovation in European firms across a range of industries and business enterprises. It is widely recognized as a unique instrument for understanding innovation and for benchmarking performance by sector and country.

The sample, supplied by the Italian National Institute for Statistics, contains 37,026 observations and is highly representative of the population of Italian manufacturing firms. The sub-sample for the food industry (ATECO[2] 10–11) has 703 observations and therefore represents 1.2% of the average number of food companies for 2008–2012 (that is 58.265) according to Eurostat statistics. Moreover, it is constituted by 82.5% of SMEs and 17.5% of large companies; in that regard, it should be noted that large companies are overrepresented, since they usually correspond to less than 1% of food firms in Italy according to Eurostat statistics.

In order to address the research questions, variables related to innovation (product and process) and those referred to external knowledge sourcing (proxy for CII) are selected from the CIS surveys and constitute respectively dependent and independent variables; moreover, the variable CIS12 is introduced to account for differences in data collecting and time between the two different surveys (Table 1). Furthermore, definitions of variables according to the CIS questionnaires and descriptive statistics are reported in Table A1 and A2, respectively (see the Appendix).

Table 1. List of variables

Dependent Variables	**CIS Code**	**Scale of Measurement**
New or significantly improved goods introduced	INPDGD	0: No 1: Yes
New or significantly improved methods or manufacturing or producing goods or services introduced	INPSPD	
Independent Variables	**CIS Code**	**Scale of Measurement**
External R&D	RRDEX	0: No 1: Yes
Acquisition of machinery/equipment/software	RMAC	
Cooperation	CO	
Acquisition of external knowledge	ROEK	
New methods of organizing external relations with other firms or public institutions	ORGEXR	
External information: from supplier of equip. material, etc.	SSUP	0: not used 1: low 2: medium 3: high
External information: from competitors or other companies	SCOM	
External information: from consultants, commercial labs	SINS	
CIS12 sample	CIS12	0: No 1: Yes

[2] ATECO is the acronym for "Attività Economiche", namely the classification of Italian economic activities (for further details, please see http://www.istat.it/it/strumenti/definizioni-e-classificazioni/ateco-2007). It is the Italian translation of Eurostat's NACE Rev. 2, which in turn stands for "Nomenclature statistique des activités économiques dans la Communauté européenne" and is the classification of economic activities made by European Community (http://ec.europa.eu/eurostat/statistics-explained/index.php/Business_economy_by_sector_-_NACE_Rev._2). In our paper we make reference to the categories ATECO 10 (Food industries) and ATECO 11 (Beverage industries), which correspond respectively to NACE 2.1 and NACE 2.2.

According to the empirical literature (Ciliberti et al. 2015; Nieto and Santamaria 2007), an extension of probit known as bivariate probit has been performed to estimate models as it takes into account the categorical nature of the dependent variables as well as the fact that product and process innovation (and, as a consequence, the error terms of the models performed) are likely to be correlated (Greene 2012). More in detail, the study applies the same two basic models to analyze the relationships between types of innovation and drivers related to external knowledge sourcing in the food industry, by comparing SMEs and large companies. The bivariate probit model has the following specification:

$$Z_{i1} = \beta'_1 x_{i1} + \epsilon_{i1}; \qquad y_{i1} = 1 \text{ if } z_{i1}>0, \qquad y_{i1} = 0 \text{ if } z_{i1} \leq 0,$$

$$Z_{i2} = \beta'_2 x_{i2} + \epsilon_{i2}; \qquad y_{i2} = 1 \text{ if } z_{i2}>0, \qquad y_{i2} = 0 \text{ if } z_{i2} \leq 0,$$

$$(\epsilon_{i1}, \epsilon_{i2}) \sim N(0, 0, 1, 1, \rho).$$

To summarize, the bivariate probit model is used for: all food companies (models 1.1 and 1.2), food SMEs (models 2.1 and 2.2) and large food companies (models 3.1 and 3.2). They were estimated with Stata 12 routine, using the standard maximum likelihood procedure.

Results

The correlation coefficient (ρ) between the residuals of each of the two probits resulted highly significant in all the models run. It shows that the error structures of the equations are correlated and that therefore the bivariate model is the most appropriate one as well as the correct specification rather than separate (univariate) probit estimation. Moreover, the Wald test also indicates high joint significance of the variables for both models.

Estimates highlighting the impact of different external knowledge sourcing activities on innovation activities, according to the type of innovation and company size are reported in Table 2. Going into detail, model 1.1 shows that external R&D activities (RRDEX) as well as the acquisition of machinery and equipment (RMAC) positively affect product innovation (INPDGD), since coefficients are respectively +0.397 and +0.492. Moreover, external information provided in particular by competitors (SCOM) and suppliers (SSUP) and, to a lesser extent, by consultants and commercial labs (SINS) is significantly able to foster product innovation activities. Coefficients are, indeed, respectively +0.206, +0.151 and +0.117. Last but not least, also the acquisition of external knowledge (ROEK) and methods of organizing external relations (ORGEXR) with other firms or public institutions (by means or alliances, partnerships, etc.) have a significant and positive impact on the introduction of new products (+0.354 and +0.281, respectively). As concerns process innovation (INPSPD), model 1.2 reveals that the acquisition of machinery and equipment (RMAC) strongly induces the introduction of new processes (+1.078). Furthermore, food companies also highly rely on information from suppliers of equipment and materials (SSUP; +0.443) as well as on acquisition of external knowledge (ROEK) in order to develop new processes (+0.468).

Table 2. The bivariate probit regression models

	All Food				SMEs				Large			
	Model 1.1		Model 1.2		Model 2.1		Model 2.2		Model 3.1		Model 3.2	
	INPDGD		INPSPD		INPDGD		INPSPD		INPDGD		INPSPD	
RRDEX	0.397	**	0.231		0.315		0.518	**	0.399		-0.321	
RMAC	0.492	**	1.078	***	0.553	***	1.203	***	0.268		0.818	**
CO	0.164		0.336		0.224		0.435	*	-0.515		0.066	
ROEK	0.354	*	0.468	**	0.517	**	0.614	**	-0.296		-0.217	
ORGEXR	0.281	*	0.099		0.223		0.034		0.993	**	0.431	
SSUP	0.151	**	0.443	***	0.088		0.402	***	0.323	**	0.515	**
SCOM	0.206	**	0.038		0.140	*	0.033		0.591	**	0.055	
SINS	0.117	*	0.064		0.129	*	0.072		0.402	**	0.114	
CIS12	0.441	***	0.006		0.492	***	-0.002		0.355		-0.051	
Overall Model Fit												
Log pseudolikelihood	-665.145				-540.383				-106.220			
Number of observations	703				580				123			
Wald test of full model: χ2	446.970***				328.54***				60.89***			
Wald test of rho: χ2	17.639***				122.466***				371.448**			

*<0.100, **<0.050, ***<0.001
Source. Author’s calculation based on CIS10 and CIS12 data

The remaining models (2.1-3.2) highlight how relationships between external knowledge sourcing and innovation differ according to food company size. Starting from SMEs, it should be noted that in both models 2.1 and 2.2 external knowledge sourcing inducing SMEs innovation activities are partly the same of those analyzed in model 1.1 and 1.2, due to the high relevance of SMEs in the sample. More in detail, model 2.1 shows that product innovation (INPDGD) is significantly and positively affected by RMAC (+0.553), ROEK (+0.517), SCOM (+0.140) and SINS (+0.129). Furthermore, model 2.2 illustrates that the introduction of process innovation (INPSPD) is fostered by RMAC (+1.203), ROEK (+0.614) and SSUP (+0.402), like in model 1.2, with a significant contribution also of RRDEX (+0.518) and of the collaboration with other enterprises or institutions (CO, +0.435).

Concerning large food companies, model 3.1 points out that they significantly rely on methods of organising external relations with other firms or public institutions (ORGEXR, +0.993), as well as on information provided by competitors (SCOM, +0.591), consultants (SINS, +0.402) and suppliers (SSUP, +0.323), to develop new products. Moreover, model 3.2 reveals that both the acquisition of external technology (RMAC, +0.818) as well as information from suppliers (SSUP, +0.515) have a positive impact on process innovation activities.

Furthermore, since the main purpose of the present paper is to shed lights on the role played by different external knowledge/technology sources according to company size, further elaborations are provided in order to better point out significant differences between SMEs and large companies. To this aim, Wald-type tests of nonlinear hypotheses were performed in order to assess the existence of significant differences between the coefficient of the estimated models.
Table 3 reports the results of Wald-type tests of nonlinear hypotheses. It shows that according to the type of innovation, some significant differences among SMEs and large companies exist.

Table 3. The Wald-type tests of nonlinear hypotheses: SMEs vs. large companies

	INPDGD Model 2.1 vs 3.1		INPSPD Model 2.2 vs 3.2	
RRDEX	0.04		4.020	**
RMAC	0.66		1.200	
CO	2.45		0.680	
ROEK	2.4		3.110	*
ORGEXR	5.05	**	1.170	
SSUP	1.68		0.470	
SCOM	4.280	**	0.010	
SINS	1.420		0.050	
CIS12	0.14		0.020	

*<0.100, **<0.050, ***<0.001
Source. Author's calculation based on CIS10 and CIS12data

As concerns product innovation (INPDGD), it should be noted that there is a significant difference in the way the new methods of organizing external relations with other firms or public institutions (ORGEXR) trigger the introduction of new products. Indeed, according to models 2.1 and 3.1, large companies take more advantage than SMEs from such relations in order to develop innovative products. Likewise, a significant difference between large companies and SMEs concerns the role played by the information provided by competitors (SCOM); indeed, results highlight that the former more effectively rely on such information source than SMEs, corroborating the empirical evidence of models 2.1 and 3.1.

With regard to process innovation (INPSPD) the comparison between models 2.2 and 3.2 outlines a couple of significant differences between large companies and SMEs, as concerns the role played by external R&D activities (RRDEX) and the acquisition of external knowledge (ROEK) in triggering the adoption of new processes. Indeed, according to the above-mentioned models, results of the Wald tests confirm that *extra moenia* R&D differently affect process innovation, since SMEs are more able than large companies in exploiting such activities in order to introduce new processes. Likewise, existing knowledge acquired from other enterprises or organizations differently affects the ability to develop new or significantly improved processes of SMEs and large companies. Biprobit models point out that the former rely more than the latter on external know-how from other enterprises or organizations to carry out process innovation activities.

Discussion

Henceforth empirical findings are discussed in the lights of existing literature, according to the research questions which the present work is based on.

As concerns RQ 1 (*What is the impact of different means of external knowledge sourcing on product and process innovation?),* models 1.1-1.2 show that in the Italian food industry both types of innovation rely on different external knowledge sources. As a consequence, the ability to internalize external knowledge of food companies is increasingly impacting positively on innovation and such a phenomenon suggests that CII gains momentum. On the basis of the previous literature, empirical findings confirm that competencies and technologies external to the food industry are becoming decisive in order to stimulate innovation, therefore building the basis for the CII (Malerba 2002; Costa et al. 2015).

More in detail, with regard to product innovation (INPDGD), model 1.1 shows that food companies greatly benefit from the acquisition of machinery (RMAC), external R&D activities (RRDEX) as well as from acquisition of external knowledge (ROEK), in order to increase their stock of knowledge. This result confirms that such an innovation takes advantage of sharing and absorbing new knowledge from outside the firm (Veugelers and Cassiman 2005; Ruben et al. 2006; Dingler and Enkel 2016). In practice, the acquisition of equipment has become unavoidable, and therefore companies have to exit the borders of their sector to enhance their competitiveness (Lee et al. 2010). The combined effect of engaging in external R&D activities and purchasing input and knowledge from other industries trigger a process that help companies face competition in diversified markets (Klevorick et al. 1995; Lee et al. 2010). Furthermore, the development of new products in the Italian food industry is also induced by new methods of organizing external relationships (ORGEXR), confirming that new organizational procedures (e.g. alliances and partnerships) are useful and also necessary to acquire knowledge from outside company and sector boundaries, as in the case of CII, due to the resource complementarity of industries involved (King et al. 2003). Last but not least, information provided by suppliers (SSUP), competitors (SCOM) and consultants (SINS) is able to foster the introduction of new products because it can help companies to decrease the risk of product failure as well as to scan the market and identify new opportunities (Avermaete et al. 2004; Stewart-Knox and Mitchell 2003; Wei and Wang 2011).

Regarding process innovation (INPSPD), findings from model 1.2 show that it is strongly induced by the acquisition of technology (machinery and equipment) from outside sectorial boundaries (RMAC). Indeed, this type of innovation is notoriously technology-pushed and, to this end, it takes advantage of the technology transfer process that allows knowledge absorption often embodied into new materials (Lee et al. 2010). In that regard, the fact that information provided by suppliers (SSUP) is also significantly able to foster the development of new processes substantiates the fact that information sharing is essential in the technology transfer processes as it leads to an increase in trust and commitment in the relationship between supplier and buyer (Lee et al. 2010). Lastly, model 1.2 also highlights that acquisition of external knowledge (ROEK) is an effective way to improve the innovation output and allows to funnel different streams of knowledge towards successful innovations (Ahuja and Ritala 2001). Most importantly, this finding could be a clear signal of CII, since purchasing and/or licensing patents and know-how from other industries is almost unavoidable to get external knowledge and develop a new process.

With regard to RQ 2 *(Do means of external knowledge sourcing differently affect innovation according to company size?*), empirical evidence show that, apart from the well-known differences between product and process innovation, some interesting dissimilarities emerge in the way external knowledge (and technology) sourcing affects innovation according to company size. Interestingly, even though the acquisition of external knowledge (RRDEX) significantly affect product innovation (INPDGD) in the general model, it is not significant neither for SMEs nor large food companies. These counter-intuitive findings stem from the small sub-sample sizes that represents one of the main limitation of the present study. Notwithstanding, it should be noted that both large food companies and SMEs benefit of technology and knowledge from outside sectorial boundaries (though with different intensity) in order to carry out innovation. This fact confirms that, even though large companies and SMEs are recognized as being different in their innovation behavior (Hamilton 1985), for both there is an increasing importance of knowledge and technology coming from outside the food sector in order to share capabilities and achieve competitive advantage (Capitanio et al. 2010).

More in detail, with reference to product innovation (INPDGD), SMEs rely more on the acquisition of equipment and machinery (RMAC), whereas empirical evidence showed that large companies are significantly more able to benefit from organizational procedures aiming to reinforce external relations (ORGEXR) as well as to absorb information mainly from competitors (SCOM). This difference could be explained by the fact that, on the one hand, for SMEs it is easier to purchase equipment in order to "exit" the borders of the food industry, get the knowledge embodied into these inputs and take advantage of the technology transfer process (Lee et al. 2010), whereas, on the other hand, large companies are more willing to change managerial practices as well as they have more resources to invest in adapting organizational procedures, like an "open innovation department", in order to acquire knowledge from outside their boundaries (King et al. 2003). This capability can induce innovation and might lead to superior performance (Schmidt and Rammer 2007; Mol and Birkinshaw 2009; Doran 2012). Accordingly, large food companies show a greater ability to access to different sources of information which are external to their boundaries, so as to merge their internal know-how with that of competitors and consultants. Such an aptitude makes them more efficient in developing innovation, since, according to Tether and Tajar (2008), diverse information sources merged with existing know-how allow to create new knowledge useful for innovation.

As concerns process innovation activities (INPSPD), the differences between SMEs and large companies lie in the fact that these latter are significantly more inclined to take advantage of external R&D (RRDEX) and external knowledge (ROEK) in order to reduce risks linked to the innovation process and to fill knowledge gaps. In addition, SMEs rely more on collaboration activities (CO), whereas both SMEs and large food companies rely on information from input suppliers (SSUP). A plausible explanations could be that, since SMEs usually lack the needed resources and capabilities to put new ideas into practice, they are more willing to get external technology by engaging in external R&D, purchasing patented inventions and collaborating with other firms or institutions in order to complement their missing resources and competencies (Ahuja and Katila 2001; King et al. 2003). On the other hand, large companies prefer to acquire information coming from suppliers so as to merge it with their internal know-how and incorporate such an external knowledge into new processes. In addition, according to Lee et al. (2010) large companies also benefit from information sharing that is essential since it contributes to increase trust between suppliers and buyers when new equipment is acquired (especially in the case of high asset specificity). Last but not least, the technology-driven nature of the process innovation is substantiated by the fact that the acquisition of machinery and equipment (RMAC) represents a key driver in fostering the introduction of new processes both for large companies and SMEs. This type of innovation is indeed closely linked to a technology transfer process as, according to Lee et al. (2010), new knowledge is often embodied in the new material, and this latter is acquired in order to absorb it. Mostly, the acquisition of technology is unavoidable, especially in technology-push processes in order to improve innovation performance and overall competitiveness.

Concluding Remarks

This paper represents an attempt to evaluate the role that external knowledge and technology sourcing is playing in product and process innovation in the Italian food industry—a sector dominated by SMEs and few large (multinational) companies—since it enables information and capability sharing to better profit by the resource endowment differences, thus facilitating the implementation of CII. Both types of companies could also benefit from a stronger technology transfer process across convergent sectors, in order to overcome the existing "cognitive distance" by reciprocally exploiting resource complementarity. It follows that the ability to acquire knowledge from outside the company boundaries as well as to collaborate with external partners and establish stable relations along the supply chain can make the difference in orienting companies towards a CII pathway. Such a route could be mainly covered by food firms that are more open to external inducement and more able to convert them in innovation, gaining then competitive advantage.

Empirical findings offered interesting insights on the role played by external knowledge sourcing on both types of innovation. Results highlight that in the Italian food industry product and process innovation takes advantage of the acquisition of machinery and equipment and external knowledge, which allow food companies to transfer know-how from outside to inside firm boundaries. Notwithstanding, product innovation in the food sector largely benefit from external R&D activities, that complement those carried out internally, as well as of organizational arrangement aimed to foster external relations and to exploit external knowledge and source of information. On the other hand, a technology-driven activity, like process innovation, relies mostly on tight collaboration with external partners, acquisition of know-how from other enterprises and on information provided by suppliers of input.

More interestingly, the paper allows focusing on peculiarities and differences between SMEs and large food companies. Our empirical analysis points out that there are some interesting analogies according to company size in the way external knowledge sourcing affects innovation. First, the technology transfer process linked to the acquisition of advanced equipment plays a key role both for SMEs and large companies' process innovation activities. Second, information from consultants plays a significant role in fostering the development of new products irrespective of company size. In this case, knowledge transfer allows firms to have deeper market knowledge, decrease the risk of failure, and implement product innovation more effectively when introducing new products (Avermaete et al. 2004; Wei and Wang 2011). Third, another common feature is that process innovation is relevantly induced by the information exchange between buyers and suppliers that allow merging internal know-how with knowledge stemming from other industries (Lefebvre et al. 2015). Information sharing, moreover, improves relationships between contracting parties and leads to an increase in trust and commitment (Lee et al. 2010). With regard to the main significant differences between SMEs and large companies empirical evidences highlight that, whereas the former strongly rely on acquisition of external R&D and knowledge in order to foster process innovation, the latter are willing to introduce new organizational methods to manage external relationships, as well as are able to use information provided by suppliers in order to trigger the introduction of new products.

In conclusion, the paper points out that, in the Italian food industry, in order to develop new products and processes both SMEs and large firms used to internalize external knowledge and R&D activities and acquire technology from outside as well as relied on information provided by suppliers, competitors, and consultants.

Findings offer interesting insights to practitioners since they shed lights on the relevance of different external knowledge sourcing activities as well as contribute to revealing main strategies of information and technology transfer adopted by food companies. Since the capability to internalize knowledge from outside the firm boundaries and rapidly convert it into innovation could increasingly represent a strong competitive advantage in order to face the agri-food market challenges in the next decades, outlining drivers which can constitute the basis for CII might help managers and stakeholders to focus on specific strategies according to company size and other relevant features.

It seems quite evident from our findings that managers and stakeholders should formulate strategies aimed at innovating their products and/or processes by investigating opportunities also in other sectors. Both large companies and SMEs can gain an advantage by investing time and resources in acquiring knowledge and technology from outside the boundaries of the food sector. Therefore, especially in the Italian food sector, companies should be more aware that innovation is fundamental to survive in the market, and also that collaborations and partnerships are necessary to complement resource and capability gaps. Finally, together with market-driven innovation, information from suppliers, competitors, and consultants as well as knowledge embodied into equipment coming from other sectors can lead to successful ideas and inventions to be put in practice.

Main limitation of the study is due to the fact that empirical analyses are based on a sample that is not properly representative of the whole Italian food industry, as well as to the limited number of large companies in the sample. Therefore caveats that stem from the biased composition of the CIS sample according to size must be considered for a more appropriate interpretation of results. Furthermore, the availability of panel data could have enabled a more thorough analysis of the dynamics that have affected the relationship between external sources of knowledge and innovation in the last decade, but it is well-known that the CIS does not provide time-series data. Moreover, it has to be considered that data about effective CII activity are not available, and the capacity to acquire external knowledge sources is used as a precursor for CII. Therefore, results are a subjective view of the authors concerning this issue and want to provide a scenario behind innovation activities of food firms in Italy, but cannot ensure that CII is really in place. Also, at present, the paper does not investigate other types of innovation, such as market or organizational innovation, which may help to depict a complete overview of food firms' innovation activities and related drivers.

All these things considered, it follows that additional research is strongly recommended to explore such a relevant topic, in order to fill the knowledge gap of CII in the agri-food sector as a whole.

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Appendix

Table A1. Definition of variables according to CIS 2010 and CIS 12 Surveys Questionnaires

Variable (CIS code) *	Question
INPDGD	During the three years 2008 (2010) to 2010 (2012), did your enterprise introduce new or significantly improved goods?
INPSPD	During the three years 2008 (2010) to 2010 (2012), did your enterprise introduce new or significantly improved methods of manufacturing or producing goods or services?
RRDEX	During the three years 2008 (2010) to 2010 (2012), did your enterprise engage in external R&D (creative work performed by other enterprises (including other enterprises or subsidiaries within your group) or by public or private research organizations and purchased by your enterprise)?
RMAC	During the three years 2008 (2010) to 2010 (2012), did your enterprise engage in acquisition of advanced machinery, equipment or software to produce new or significantly improved products and processes?
CO	During the three years 2008 (2010) to 2010 (2012), did your enterprise co-operate on any of your innovation activities with other enterprises or institutions? (e.g. innovation co-operation is active participation with other enterprises or non-commercial institutions on innovation activities. Both partners do not need to commercially benefit. Exclude pure contracting out of work with no active co-operation.).
ROEK	During the three years 2008 (2010) to 2010 (2012), did your enterprise engage in acquisition of other external knowledge (e.g. purchase or license patents and non-patented inventions, know-how, and other types of knowledge from other enterprises or organizations for the development of new or significantly improved products and processes)?
ORGEXR	During the three years 2008 (2010) to 2010 (2012), did your enterprise introduce new methods of organising external relations with other firms or public institutions (i.e. first use of alliances, partnerships, outsourcing or sub-contracting, etc.)?
SSUP	During the three years 2008 (2010) to 2010 (2012), how important to your enterprise's innovation activities were information sources from suppliers of equipment, materials, components, or software?
SCOM	During the three years 2008 (2010) to 2010 (2012), how important to your enterprise's innovation activities were information sources from competitors or other enterprises in your sector?
SINS	During the three years 2008 (2010) to 2010 (2012), how important to your enterprise's innovation activities were information sources from consultants, commercial labs, or private R&D institutes?

Note. (*) The variable CIS12 is a control variable not included in the CIS questionnaires.

Table A2. Relative and absolute frequency by company size

Variable (CIS code)	Value	ALL (n=703)		SMEs (n=580)		LARGE (n=123)	
		Rel. Freq.	Abs. Freq.	Rel. Freq.	Abs. Freq.	Rel. Freq.	Abs. Freq.
INPDGD	0	0.514	361	0.557	323	0.309	38
	1	0.486	342	0.443	257	0.691	85
INPSPD	0	0.543	382	0.576	334	0.390	48
	1	0.457	321	0.424	246	0.610	75
RRDEX	0	0.885	622	0.912	529	0.756	93
	1	0.115	81	0.088	51	0.244	30
RMAC	0	0.444	312	0.469	272	0.325	40
	1	0.556	391	0.531	308	0.675	83
CO	0	0.890	626	0.921	534	0.748	92
	1	0.110	77	0.079	46	0.252	31
ROEK	0	0.888	624	0.890	516	0.878	108
	1	0.112	79	0.110	64	0.122	15
ORGEXR	0	0.818	575	0.834	484	0.740	91
	1	0.182	128	0.166	96	0.260	32
SSUP	0	0.378	266	0.417	242	0.195	24
	1	0.095	67	0.095	55	0.098	12
	2	0.329	231	0.312	181	0.407	50
	3	0.198	139	0.176	102	0.301	37
SCOM	0	0.586	412	0.617	358	0.439	54
	1	0.229	161	0.219	127	0.276	34
	2	0.132	93	0.112	65	0.228	28
	3	0.053	37	0.052	30	0.057	7
SINS	0	0.457	321	0.490	284	0.301	37
	1	0.211	148	0.178	103	0.366	45
	2	0.235	165	0.234	136	0.236	29
	3	0.098	69	0.098	57	0.098	12
CIS12	0	0.613	431	0.634	368	0.512	63
	1	0.387	272	0.366	212	0.488	60