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To Make or to Buy: Is this the Question?

Testing making or buying decisions to explain innovation sourcing strategies in the food sector

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Abstract

This paper analyses the decision of food companies to realize innovations through in-house activities, outsourcing and suing collaborations. The paper uses information from a dataset of 389 Italian food companies collected by Unicredit group in 2007. We develop a set of hypotheses from three theoretical perspectives: transaction cost economics, strategic management and resource-based view. This paper aims at highlighting what firm's features are related to the make, buy and mixed innovation-sourcing decisions. We found that these strategies are positively interlinked which is challenging current theories. We conclude the paper by discussing these results and bringing some interesting outcomes to discuss managerial implications and/or policy interventions in this highly strategic domain.

Keywords: Making or buying decisions, innovation sourcing strategy, innovation, food industry.

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Introduction

Managers and practitioners evolving in the food industry know that innovation is a key-issue for their company success (Rama 2008). Innovations keep consumers aware of product attributes, create market segmentation and quality-premium opportunities, and increase knowledge and capabilities within the organization (Traill and Meulenberg 2002; Omta and Folstar 2005; Pascucci et al. 2011). However only a minority of food companies dare to innovate, and if they do, prefer to combine in-house and outsourced projects, for example through collaboration with other companies or knowledge institutions and simultaneously buying technology on the market. Why? A reason frequently mentioned is that in the food industry, innovation processes are becoming more and more complex, maybe even more than other sectors (Rama 2008; Capitanio et al. 2010; Enzing et al. 2011). This is explained by the so-called uniqueness of food innovation processes: companies dealing with innovative projects are squeezed by technology-push and demand-pull forces simultaneously (Grunert et al. 1997; Rama 2008). On the one hand, an almost continuous technological development (i.e. in the ICT domain) compels food companies to continuously adopt new technologies, restructuring and updating their activities and related capabilities. On the other hand, retailers impose strict quality standards and requirements on food companies, with low returns and high risks. On top of that, raw materials (agricultural products) are becoming increasingly expensive, or complex to source worldwide. Therefore food companies' decisions on whether and how to innovate are gaining more and more importance over time.

Despite the recognized relevance of this topic, the literature on innovation sourcing strategy has not yet been very prolific in the food sector (Pascucci et al. 2011). One of the main persistent issue in food innovation is that new food products generally have a relatively low success rates (Stewart-Knox and Mitchell 2003; Enzing et al. 2011). Notwithstanding this phenomenon, it is still unclear why so many European food companies do not show significant efforts in innovative investments and R&D activities (Rama 2008).

However, if factors affecting the decisions of food companies to innovate and how to innovate could be better understood, more effective policy actions and managerial strategies could then be undertaken. In this paper, we propose a first step to address this issue, and to cover this gap.

Looking back at the literature on the organization and management of innovation processes, decisions to innovate "in-house", to "collaborate" or to "outsource" are considered as an important aspect of companies' strategies (Becheikh et al. 2006; Cassiman and Veugelers 2006). Previous studies investigating the decisions of manufacturing companies to make or buy innovations have been mainly supportive of both the transaction costs theory (Williamson 2000; 2002) and the property rights approach developed by Grossman, Hart and Moore (Grossman and Hart 1986; Hart and Moore 1990; Klein 2005). In these studies making or buying decisions are often seen as substitute rather than complement.

However, other works from different theoretical perspectives have brought new elements relevant to these analyses. These elements relate to strategic management (Ahuja and Katila 2001) knowledge, capabilities and resource-based elements, and the contextual environment (Becheikh et al. 2006; Noteboom 2004). They suggest more complementarity between making and buying decisions.

Although better known, the mechanisms leading to outsourcing versus realizing in-house innovative investments and\or R&D activities are still far from completely understood. For instance, the literature looking at the role of dynamic capabilities such as absorptive capacity and learning processes within company networks, suggests that a strict dichotomy of "making or buying" no longer holds (Zahra and George 2002; Nooteboom 2004). A company innovates in-house if it is able to develop internal competences, for example through R&D investments, but at the same time might well develop and maintain external ties for example with research organizations, while organizing and investing in collaborative networks. Therefore, instead of conceptualizing the "make or buy" decisions as opposite alternatives, scholars should better look at them as potentially complement. Moreover, "mixed" decisions can be undertaken such as investing in collaborative networks based on R&D and learning activities, which imply both making and buying. We can conceptualize this type of organizations as hybrid forms of innovation.

This paper is concerned with this specific issue. It analyses the determinants of the make, buy and collaborative (hybrid) decisions in the food industry using a database collected by Unicredit group in 2007 that relates to 389 companies operating in the Italian food industry (fruits, vegetables, vegetal oil, wine and dairy). Following a previous approach developed in Pascucci et al. (2011), we have organized the analysis in two steps: in the first one, we formulate hypotheses on the relationship between food companies and their innovation sourcing strategies. In the second step, we use a multi-variate probit model (MVP) to test the correlation between "making", "buying" and "collaborative" decisions, and we highlight the main driving factors of innovation sourcing strategies in the Italian food sector. Our results show that in-house, outsourcing and using hybrid forms of innovative collaboration are correlated and interlinked decisions, while a clear-cut behaviour between food companies that make and the ones that buy innovations cannot be draw based on our empirical evidence.

This paper proceeds as follows. In section 2, we introduce the concept of innovation as used in this paper and we elaborate on the theoretical elements used to develop our hypotheses. In section 3, we present our empirical analysis with a first glance at some descriptive statistics before introducing our empirical model. Section 4 shows the results while in section 5 we discuss and conclude with policy and managerial implications.

Theoretical Framework

Innovation in the Food Sector

Though similar to other manufacturing sectors, innovation processes in the food sector are conditioned by a relatively higher degree of uncertainty. This is due to the key role played by bio-based products. Bio-based products have a greater fluctuating quality than manufactured products, due to the perishable nature of agricultural products and the unpredictable weather conditions affecting the quantity and quality of products (Pascucci et al. 2011). Food companies have often to deal with very heterogeneous farmers/suppliers. These features of the food sector add to the existing uncertainty of the innovative activities (Pascucci et al. 2011). Moreover, new food products have generally a relatively low success rates (Grunert et al. 1997; Enzing et al. 2011). Finally, innovation outsourcing has a greater importance within the food industry, where R&D intensity could be a non-exhaustive indicator to catch the innovativeness (Galizzi and Venturini 2008).

The decision to outsource innovative activities or R&D has to take into account a number of peculiarities that lie in the distinctive nature of innovation compared to other goods or activities (Howells et al. 2008). Howells et al. (2008: 206) have made an exhaustive inventory of these peculiarities. First, the outcome of the outsourced innovation is highly uncertain and risky compared to other activities (Doctor et al. 2001). As mentioned by Veugelers and Cassiman (1999), given their uncertain returns and short life cycles, investments in risky sunk R&D expenditures have taken an overriding importance in the survival of companies. Second, the firm outsourcing cannot evaluate the quality of the knowledge that is transferred to them by the supplier (Howells et al. 2008). Third, the fact that the supplier of an innovation often does not know the quality of the knowledge it sells, because it does not know the future outcomes of its innovation, may lead to contractual incompleteness problem related to intellectual property exchange (Howells et al. 2008). Fourth, both partners, the firm and the customer, are involved in a co-joint production of new knowledge which may lead to intellectual property rights rent-sharing issues (Howells et al. 2008). Fifth, innovation outsourcing may lead to a whole set of moral hazard problems such as the use of the knowledge transferred to the supplier for other customers (Howells et al. 2008). Sixth, if outsourcing goes wrong, the future of the firm can be threatened given the importance of R&D and innovation as core competences and capabilities of companies (Howells et al. 2008). Seventh, outsourcing decisions have an irreversible effect on R&D or technical capacity of the firm (Howells et al. 2008). Eighth, the exchange of information during the outsourcing process is a unique event, which limits the capacity of companies to learn from experience (Howells et al. 2008). Ninth, tacit nature of the know-how exchanged when outsourcing makes it difficult to monitor contracts (Howells et al. 2008). These characteristics are not unique to innovation *per se*, other outsourced activities also show these features, but their combination surely is.

Determinants of the Make or Buy Decision

The make or buy decision applied to a company innovation sourcing strategy is receiving increasing attention in the literature. Outsourcing innovation allows companies to tap into advanced knowledge and technology, as well as to obtain a cost advantage (Ulset 1996; Gooroochurn and Hanley 2007). The downside of these advantages, especially when outsourcing innovation, is that control loss, maladaptation, technology leakages and hold-up[1] situations may incur costs. Many works looking at the make or buy issue have been performed in the last fifteen years in various industries: Ulset (1996) on Norwegian information technology industry; Veugelers and Cassiman (1999) on the Belgium manufacturing industry; Love and Roper (2001); Roper and Love (2002) on UK manufacturing plants; Love and Roper (2005); Howells et al. (2008) on UK pharmaceuticals; Gooroochurn and Hanley (2007) on UK companies. Although the transaction cost theory has proved to be quite successful in explaining the decision of companies to make in-house or to outsource activities, the relevance of this theoretical framework seems to be limited when it comes to explain innovation sourcing strategies.

A number of authors have argued that companies faced with the decision to innovate in-house or to outsource are more motivated by strategies (Gooroochurn and Hanley 2007; Howells et al. 2008) or resources (Conner and Prahalad 1996; Love and Roper 2005; Nooteboom 2004) rather

[1] A hold-up is a term used to describe a situation in which one of the partner to a transaction uses its bargaining power opportunistically to extract rents from another partner 's specific investments.

than transaction costs considerations. When investigating the determinants of the make or buy decision applied to innovation outsourcing, transaction costs but also competence/resource-based approaches and strategic reasons must be taken into account. Based on these considerations, we decided to rely on the three theoretical approaches aforementioned (transaction cost economics, strategic management and resource-based view). In this section, we review the literature on the make or buy innovation determinants drawn from these three perspectives and develop hypothesis to be tested.

Transaction Cost Economics

Transaction costs economics makes the assumption that efficient production requires specific investments that will enable companies to reduce production costs, innovate and meet customers' requirements. However, these specific investments create a bilateral dependency that may lead to hold-up hazards. As a matter of fact, because these specific investments have a lower value in alternative uses, partners to an exchange with such investments may act opportunistically to appropriate the quasi-rent created by them through post-contractual bargaining or threats of termination, creating transaction costs. In order to minimise transaction costs, contractual partners will either seek to develop safeguards such as stronger administrative control rights and more exclusive property rights, or to internalise the transaction, that is to make in-house. Transaction costs economics thus argues that companies incurring heavy sunk costs in R&D expenditures will want to protect these investments from opportunistic behaviour by innovating in-house (Gooroochurn and Hanley 2007). Thus, the following hypothesis is formulated.

Hypothesis 1. Companies having high investment costs in R&D will more likely undertake in-house innovation sourcing.

Another factor that can influence a firm to outsource innovation activities is related to the nature of the other contracting activities of the firm, such as network relations (Becheikh et al. 2006). These include the linkages between the food firm and other agents of the food chains (agriculture, distribution operators, etc.) and deal with the attitude to enter in formal and/or relational networks (consortia, production-based association, manufacturing joint-ventures, informal contracts, etc.). These linkages allow companies to share information and "know-how", reduce contractual uncertainty and have access to group resource (Teece 1996). According to transaction costs economics, companies involved in a network experience lower transaction costs. Since our database contains data on being part of a holding/group and participating in a consortium, we make the following hypothesis.

Hypothesis 2. Companies that are part of a holding/group or a consortium are more likely to outsource and/or use hybrids.

Strategic Management

As mentioned previously, outsourcing innovation is particular compared to other activity outsourcing since there is a potentiality for R&D findings to be disclosed by the research partner or subcontractor (Becheikh et al. 2006). Rents from investments in innovation might then be dissipated. In this section, we draw three hypotheses that take into account companies' strategic concerns when deciding to make or buy innovation.

One of the strategic factors cited in the literature that might influence the make or buy decision concerns the market structure. In order to protect their market positions, companies in concentrated markets will have an incentive to innovate in-house so as to reduce the risk of disclosure and to prevent or delay rivals' imitations (Love and Roper 2001; Smolny 2003). In a study on the Dutch manufacturing sector, Hertog and Thurik (1993, 283) mention "Internal R&D may give a firm a valuable lead time over its rivals in a concentrated market." Their empirical results show that a high level of market concentration in a sector is correlated with a relatively low incidence of R&D outsourcing. Given these evidences, we pose the following hypothesis.

Hypothesis 3. Companies evolving in high market concentration will be more inclined to make innovation in-house.

The role of company size, the capacity to allocate financial resources to internal R&D is another relevant factor considered in the literature (Beneito. 2003; Greve. 2003; Becheikh et al. 2006). In this sense, large companies with strong market power show higher investments in innovation activities than the small ones, for example due to larger cash flow generated by monopolistic power, and to a better access to capital market (Arundel and Kabla 1998; Acs and Audretsch 1998; Bougrain and Haudeville 2002; Beneito 2003). However, other authors deeply contested this point of view, according to the idea that small and medium companies (SMEs) are more adaptable to the market conditions, more open to "innovation joint-venture" and "contracting strategies" ("buying" innovation activities) (Omta 2002; 2004) and less constrained by the transaction costs of bureaucratic and managerial structures (Teece 1996; Teece at al. 1997; Becheikh et al. 2006). Moreover, SMEs show a higher internal flexibility (related to the organization of the production and to decision making processes), a better flow of internal communication, greater specialisation possibilities, as well as a higher informal and strategic control (Galende and de la Fuente 2003). Since the relationship between size and sourcing strategy is ambiguous, we derived this general hypothesis.

Hypothesis 4. Large companies are more likely to adopt an in-house innovation strategy.

Veugelers and Cassiman (1999) have noticed that process and generic product innovations are more likely to be outsourced than product and specialized innovations. Since product innovation is considered as a firm-specific input, leakage through outsourcing has more important strategic implications than for generic process innovations. The supplier firm cannot use leakage over generic R&D innovations opportunistically since most companies are contracting these innovations. Therefore, similar to Gooroochurn and Hanley (2007), we make the following hypothesis.

Hypothesis 5. Process innovation is more likely to be outsourced, or realized through hybrids than product innovation.

Resource-Based View

Approaches based on resources claim that we need to incorporate capabilities and competences in governance analysis since they have an impact on the efficiency of alternative governance structures (Teece 2007; 2009; Nooteboom 2004). There are two complementary competence explanations for innovation sourcing choice. One assumes opportunism as a basic characteristic of human behaviour. As innovation involves activities that are often difficult to measure, it provides options for opportunistic behaviour. The choice of a governance structure has thus to be made so as to reduce the risk of opportunism. The second perspective focuses on the problem of limited cognition. It is often impossible to transfer (tacit) knowledge to other persons. By bringing the different persons working on an innovation within the boundaries of the firm, knowledge sharing is facilitated. Mason and Wagner (1994) have stressed the importance of highly skilled employees for innovation but the effect of these capabilities on the make or buy strategy is far from being unanimous. Some scholars argue that high internal competences may be an incentive for companies to innovate in-house with available resources and thus benefit from scale of operation (Veugelers and Cassiman 1999; Romijn and Albaladejo 2002). Others mention that in-house and external activities are complementary, in the sense that in-house capabilities allow companies to absorb external knowledge effectively (Cohen and Levinthal 1990; Cohen 1995). Aurora and Gambardella (1994) have argued that internal knowledge resources support using foreign know-how more effectively in the firm, which would stimulate external innovation sourcing. Since the effect of internal capabilities on innovation sourcing decision is not unanimous in the literature, we pose the following hypothesis using the percentage of employees dedicated to R&D activities as a proxy for internal resources in innovation.

Hypothesis 6. Companies with a high percentage of employees dedicated to R&D activities are more likely to innovate in-house.

The level of human quality also influences the innovation sourcing strategy of companies (Becheikh et al. 2006). The way the firm acts in order to facilitate the cumulative learning can be assessed by the rate of economic and financial resources dedicated and oriented to the professional formation and its organisation inside the firm (Romijn and Albaladejo 2002).

Hypothesis 7. Companies with a higher concentration of skilled workers are more likely to innovate in-house and/or using hybrids.

Control Variables

Contracting activities can be analysed in an indirect way, looking at the results of their influence on the firm strategies on the markets, such as internationalisation and export-orientation (Romijn and Albaladejo 2002), the degree of specialization (Hitt and Hoskisson 1988; Beneito 2003; Galende and de la Fuente 2003). The empirical literature shows a positive relationship between export orientation and innovations (Kumar and Saqib 1996; Roper and Love 2002; Beneito 2003; Galende and de la Fuente 2003), while the way product-diversification or specialisation affect firm innovation is not clearly recognized and remain still controversial (Chen 1996; Beneito 2003; Galende and de la Fuente 2003). Since export activities might have an important effect on the decision to innovate, we use it as a control variable in our model.

The age of the firm and type of ownership (for example being a cooperative or an investor-owned firm) can be used as another possible measure of its organisational complexity, potentially representing the experience and the knowledge accumulated throughout its history and the "learning" process of the firm (Galende and de la Fuente 2003; Pascucci et al. 2011). Some articles showed the higher inclination to innovate by "old" companies (Kuemmerle 1998; Freel 2003), while some other considered "young" enterprises as more active in the direction of innovation (Molero and Buesa 1996). In this sense, the age remains a controversial factor of innovation.

Other factors which might be relevant for sourcing decisions refer to the level of modernization of the company, for example, considering ICT investments, and ownership structure (i.e. being a cooperative or an investor-owned company) (Becheikh et al. 2006). Moreover, sourcing decisions are influenced by the context in which the firm operates. In other words, the geographical location and local networking of food companies are key factors behind different attitudes to innovativeness (Omta et al. 2001; Nielsen 2008). The specific location of a firm is important to understand the opportunities to use local social capital and the institutional environment as a source of knowledge and innovativeness (Becheikh et al. 2006; Capitanio et al. 2009; 2010).

Testing the Hypotheses for "Making-Buying" Decisions

Data and Descriptive Analysis

The database used in this paper comes from the 10th survey on Italian manufacturing companies carried out by Unicredit Group in 2007. It includes a sample of 389 food companies with information related to the period 2004-2006. Data include financial and economic characteristics, organization, investments, internationalization and innovation processes. The dataset distinguishes between internal, external sourcing and use of networks of collaboration and joint ventures for carrying out innovation activities. The set allows us to define the three dependent variables of our analysis as follow:

(1) "*in-house innovation*" refers to the presence of R&D activities carried out within the company, due to the presence of a specific department or division. We also take into account the presence of training activities for the employees of the company with the specific purpose of increasing the firm innovation capacities.
(2) "*out-sourcing innovation*" is whenever the company indicates that it acquired technologies, industrial equipment, machineries, patents and/or know-how from other companies with the specific purpose of introducing new processes and/or products
(3) *"hybrids"* relates to R&D activities carried out together with external entities through networks of collaboration, strategic alliances or joint ventures, for example with knowledge institutes, universities and research centres, or other companies.

One quarter of the sampled companies indicated being involved in innovative projects, 20% mentioned using both in-house and outsourcing, and 5% indicated realizing only in-house or only outsourcing innovations (Table 1).

Table 1. In-house, outsourcing and hybrid forms of innovation in the Italian food companies

		Hybrids	Outsourcing (buy)		Total
			No	Yes	
In-house	No	No	265	15	280
		Yes	0	2	2
	Yes	No	21	31	52
		Yes	8	47	55
Total			294	95	389

Source. Author's elaboration on Unicredit 2007

To empirically test our theoretical hypotheses, we use a set of variables presented in Table 2.

Table 2. Explanatory Variables and Descriptive Statistics.

Theoretical Background	Hypothesis	Variable		Statistics	
				Mean	S.D.
Transaction Cost Economics	H1	Total amount of R&D expenses 2004-2006 (000 euro) (a)	rd_tot	98.24	197.89
	H2	Being part of a holding/group (a)	holding	0.19	0.46
		Participating in a consortium (a)	consort	0.07	0.25
Strategic Management	H3	Index of market concentration (% Turn-over first 4 companies in the same sector of specialization) (b)	c4	34.00	24.40
	H4	Size (number of employees) (a)	tot_employ	54.17	92.30
	H5	Presence of product innovation (a)	in_prod	0.43	0.50
		Presence of process innovation (a)	in_proc	0.19	0.39
Resource-Based View	H6	Percentage of employees dedicated to R&D activities (a)	per_empl_rd	5.53	17.35
	H7	Number of skilled workers (a)	skilled_work	29.77	69.67
Control		Age of the firm (year) (a)	age	31.47	25.86
		Amount of investment in ICT (2006) (000 euro) (a)	inv_ict	0.54	0.58
		Being a cooperative (a)	coop	0.09	0.29
		Presence of export activities (a)	export	0.63	0.61
		Capacity of capital accumulation in the region of location (index) (c)	cap_stock	21.72	2.27
		Innovation capacity in the region of location (index) (c)	in_capac	1.10	0.34
		Percentage of public R&D expenses in the region of location (c)	pub_r_d	0.52	0.22
		Percentage of private R&D expenses in the region of location (c)	priv_r_d	0.54	0.31

Source. Author's elaboration on a. Unicredit, 2007; b. ISMEA, 2009; c. ISTAT, 2010

The Empirical Model

A widely used approach to estimate the probabilities of choosing between alternative strategies is to implement a discrete-choice model (Masten and Saussier 2002). In this case, the observed innovation strategy (i.e. in-house, outsourcing or hybrid form) is considered as an expression of a continuous latent variable reflecting the propensity to choose a specific option among different alternatives. The generic empirical model related to the company *j* to choose an innovation strategy *s* can be written as follow:

$$(1) \qquad Y_{sj}^{*} = X_{j}^{'}\beta_s + \varepsilon_{sj} \qquad \forall s \in S$$

$$(2) \qquad \begin{array}{ll} Y_{sj} = 1 & \textit{if} \quad Y_{sj}^{*} > 0 \\ Y_{sj} = 0 & \textit{otherwise} \end{array} \qquad \forall s \in S$$

where Y_{sj}^{*} is the unobservable value of the strategy *s* for company *j* (latent variable), Y_{sj} is the observable strategy choice, for s = 1 in case of in-house strategy, s = 2 in case of outsourcing and s=3 in case of hybrid form strategy. $X_{j}^{'}$ is the vector of explanatory variables for company *j*, β_s a vector of coefficients for strategy *s* and ε_{sj} a vector of unobservable characteristics related to company *j* and strategy *s* (Masten and Saussier 2002). We can derive the probability that strategy *s* is chosen by company *j* (γ_{sj}) as a function of the potential explanatory variables (Masten and Saussier, 2002):

$$(3) \qquad \gamma_{sj} = P(Y_{sj} = 1) = P(Y_{sj}^{*} > 0) = P(X_{j}^{'}\beta_s + \varepsilon_{sj} > 0) = P(\varepsilon_{sj} > -X_{j}^{'}\beta_s) = F(X_{j}^{'}\beta_s)$$

where *F* denotes the distribution function of the unobservable characteristics ε_{sj}. Different econometric strategies can be implemented accordingly to the nature of the strategic choice analysed and the distributional form assumed for *F* (Verbeek, 2008). In this case, the decision setting is about (1) innovating in-house (*making*), (2) outsourcing (*buying*) and (3) using a hybrid form. This would lead to a system of (three) equations. The implicit assumption is that the probability of making is independent from the probability of buying. But there is a high probability that the company likelihood to operate in-house is conditional to the decision whether or not to outsource, and/or use a hybrid form. In other words, these decisions are likely to be interrelated. The usual alternative would be to estimate a multivariate probit model (see also Pascucci et al. 2011). For each choice (in-house, outsourcing and hybrid form), a probit model is estimated and it is assumed that the error terms for the two equations are correlated.

As presented in Pascucci and colleagues (2011), the multivariate probit model is suitable to define company decisions to choose more than one strategies simultaneously (Greene 2008). Since the outcomes are treated as binary variables any combination of strategies is possible. The strategies can be complements rather than substitutes only. The three equations model (one for s = 1, one for s = 2, and the other for s = 3) is featured by correlated disturbances, which (due to identi-

fication reasons) are assumed to follow a normal distribution (variance is normalized to unity). That is for each j^{th} company:

$$(4) \quad \begin{aligned} & E\left[\varepsilon_{1j}\right] = E\left[\varepsilon_{2j}\right] = E\left[\varepsilon_{3j}\right] = 0 \\ & \operatorname{cov}\left[\varepsilon_{1j}, \varepsilon_{2j}, \varepsilon_{3j}\right] = \rho = \left\{\rho_{123}\right\} \\ & \operatorname{var}[\varepsilon_{1j}] = \operatorname{var}[\varepsilon_{2j}] = \operatorname{var}\left[\varepsilon_{3j}\right] = 1 \end{aligned}$$

where ρ is a vector of correlation parameters denoting the extent to which the error terms co-vary. Should this be the case, we would need to estimate the two equations jointly, following a bivariate normal distribution: $\{\varepsilon_1, \varepsilon_2, \varepsilon_3\} = \phi_3(0,0,0,1,1,1,\rho)$. Because in this model we are interested in simultaneous strategic decisions we have to define the joint probability. For example, the probability of firm *j* of choosing making and buying strategies at the same time $(Y_{1j} = Y_{2j} = Y_{3j} = 1)$ would be:

$$(5) \quad \begin{aligned} \gamma_{sj} &= P(Y_{1j} = 1, Y_{2j} = 1, Y_{3j} = 1) = \int_{-\infty}^{\varepsilon_{1j}} \int_{-\infty}^{\varepsilon_{2j}} \int_{-\infty}^{\varepsilon_{3j}} \phi_3(X'_{1j}\beta_1, X'_{2j}\beta_2, X'_{3j}\beta_3, \rho) d\varepsilon_{1j} d\varepsilon_{2j} d\varepsilon_{3j} \\ &= \Phi_3(X_{1j}'\beta_1, X_{2j}'\beta_2, \beta_3 X'_{3j}) \end{aligned}$$

In this model the log-likelihood is then a sum across the four possible strategies variables (that is, four possible combinations of innovate $(Y_{1j} = Y_{2j} = Y_{3j} = 1)$ and non-innovate $(Y_{1j} = Y_{2j} = Y_{3j} = 0)$ times their associated probabilities (Greene, 2003). These probabilities may be drawn from (5) as well. The most relevant coefficients estimated in the model are $\beta_1, \beta_2, \beta_3$ and $\rho(\rho_{123})$. The latter, if significantly different from zero, will evaluate to which extent each pair of decisions are interrelated.

Results

The multivariate probit model results indicate whether the theoretical hypotheses are verified by empirical evidence (Table 3, see Appendix). The correlation between in-house, out-sourcing and hybrid forms has been confirmed by the results. They indicate that the likelihood that a company will jointly consider using in-house, out-sourcing and hybrid forms simultaneously as sourcing strategies is positive and relatively high. This result is indeed intriguing from a theoretical perspective where often making-buying decisions are seen as alternative rather than complementary strategies (see also results from Pascucci et al. 2011). Of course, results refer to joint decisions on innovation strategies, which involve different types of innovative projects with different features. Therefore, it would be necessary to analyse in more detail the type of innovative projects implemented in-house versus out-sourced.

In hypothesis 1 *"companies having high investments costs in R&D will favour in-house innovation sourcing*". Results indicate a positive effect of R&D investments not only on in-house strategy, but also on outsourcing and hybrid forms. Therefore, according to these results, the nature of R&D investments should not be seen as leading to an increase of asset specificity of the com-

pany but, more in line with assumption of the dynamic capabilities literature, as a flexible form of assets. The companies can make use of the improved R&D capabilities (i.e. due to the financial resources allocate for their implementation) also to better look at how to outsource innovation or set up a collaborative joint venture with an external research centre.

In the hypothesis 2, we indicated "*companies that are part of a holding/group or a consortium are more likely to outsource and/or use hybrids"*. The variables used to test this hypothesis were both not significantly correlated to our dependent variables. Therefore *H2* doesn't hold according to our empirical results. Results indicate that in the food industry participation in networks, partnerships or alliances targeted to financial activities (holding) or quality and market-participation control (consortium) do not necessarily lead to the sharing of innovative projects with those partners. An explanation for these results is linked to the degree of complexity of food innovation processes, which requires targeted partners to be implemented in a collaborative form or to allow effective outsourcing.

In hypothesis 3, we indicated "*companies evolving in high market concentration will be more inclined to make innovation in-house*". This is substantially rejected by our results, which indicate a strong negative effect on the likelihood of the firm to implement in-house projects. At the same time, results do not indicate any impacts on both outsourcing and hybrid form strategies. Therefore, it seems that concentration is discouraging companies to undertake investments in internal R&D activities in the food industry.

The variable on the size of the company could not be verified either. Therefore, hypothesis 4, which states "*the size of the firm has a positive effect on in-house innovation strategy*", doesn't apply to food companies. Our results indicate that SMEs and large corporations do not differ in terms of likelihood of innovate in-house, outsource or use hybrid forms.

In hypothesis 5, we indicated that "*process innovation is more likely to be outsourced or realized through hybrids than product*". Our results partially confirm this hypothesis. While we can highlight that more process related innovations are more likely to be outsourced, it also applies to product innovations. Moreover, it seems that in-house and hybrid form strategies are used in both product and process innovation, therefore indicating that a clear-cut relationship doesn't exist.

Hypothesis 6 states that "*companies with a high percentage of employees dedicated to R&D activities are more likely to innovate in-house"*. Results indicate (*per_empl_rd*) that this hypothesis partially holds and that food companies with higher application of human capital in R&D activities are less likely to implement outsourcing innovative projects. However, a direct positive effect on in-house strategies has not been found.

Finally, looking at hypothesis 7, "*companies with a higher concentration of skilled workers are more likely to innovate in-house and/or using hybrids"*, our results don't confirm this statement while indicating a negative correlation between the concentration of skilled employees and in-house innovation decisions.

In our analysis, we also used a set of control variables, in order to better explain making and buying decisions of food companies. First, we considered the age of the company. Results indicate

that more experienced food companies showed a higher likelihood to innovate through outsourcing activities. Our interpretation is that while older food companies have more accumulated knowledge and tacit internal know-how, they are also potentially suffering from routines and internal procedures which might reduce their likelihood to innovate internally or through collaborative networking. However, longer experience in the operating sector and cumulative knowledge create capabilities to use outsourcing strategies that younger food companies might not have.

Another result found that companies that invested in information and communication technology (ICT) are more likely to both make and out-source innovation. Investments in ICT are basically linked to hardware and software technology, which is used in processing food products, manage in-bound and out-bound activities, and communicating with other chain partners. ICT technology is developed outside the food sector and intensively patenting. Therefore, food companies develop networks of collaboration where ICT-companies are less strategically involved. In contrast, ICT technology is more likely to be acquired from the market and internally adapted to company-specific problems.

Our results show that being an exporter-oriented company is positively affecting in-house strategies. Adaptation to foreign costumers' requirements and preferences is the main issue for food exporting companies. This requires a highly targeted innovative process, which may lead to internalize R&D activities more than making use of collaboration or buying technologies on the market.

Among the control variables we used to test the role of location and local interactions, only the index of the capacity of capital accumulation in the region of location has showed a significant correlation. Food companies located in area with higher intensity of investments are less likely to make innovation in-house but this situation does not necessary lead to more outsourcing strategies. It means that food companies do not fully benefit from a better environment for implementing innovative strategies. It also indicates that internal factors seem to be more relevant than external ones.

Discussion and Conclusions

Starting from empirical findings in Pascucci and colleagues (2011), and in line with previous researches on innovation in the food sector, this paper investigates the strategies used by food companies to innovate. Namely it analyses whether using in-house, out-sourcing or hybrid forms of innovation strategies are interrelated, and which driving factors can explain them. We identify a set of research hypotheses and use the empirical data to test them. However, empirical results highlight that only some of the theoretical statements can be confirmed.

The main finding of this paper is the idea that companies do innovate using interrelated strategies. In-house activities, out-sourcing, and usage of collaborative networks and\or joint ventures are part of a more general innovative attitude (capability) of food companies. However, identifying specific factors affecting those decisions remain puzzling, as already highlighted in previous papers dealing with the same topic (see for example Pascucci et al. 2011). The general picture that emerges from this analysis is that the behaviour of food companies in terms of internaliza-

tion and externalization of innovation is less differentiated than theories could predict. Another important aspect is that the control variables related to the external environment in which the company operates were less significant than expected. In the first case, we can highlight the relevance of a synergistic relationship between internalization, pure and mixed outsourcing strategies. In the second case, it could be argued that the context is less relevant than expected *a priori*.

The set of results indicates that it is complex to conceive and implement strategic actions and policies to stimulate and foster innovation processes in the Italian agro-food sector. In any case, our results indicate the need to establish a theoretical analysis more grounded on empirical findings. In particular, the results indicate the need to further test the validity of some theoretical elements such as the ability of companies to learn from other partners (absorptive capacity) and their ability to adapt to different socio-economic and institutional contexts (adaptive capacity).

Food managers and practitioners are aware that, although innovation is a key-element for successful businesses, it might also be extremely uncertain and complex to organize, especially in the food sector. This leads to the conclusion that food managers might have a risk-averse attitude, and therefore opting for "black or grey" as opposite to "black or white" options. Many food companies cannot cope with the high stakes imposed by innovative behaviour. They prefer "black" options, therefore staying out of innovative strategies and acting as laggards, or late followers. When they go for an innovative strategy, they have the tendency to combine in-house and external activities (grey options), no matter if they are large corporations or SMEs, cooperatives or investor-owned companies, belonging to a holding or a consortium of companies.

The results indicate that a clearer understanding of this decision-making process can be achieved either through the analysis of the specific innovative projects, therefore moving from a company to a project level, or from an active engagement of managers in experiments and longitudinal studies. On the one hand, project-level research can reveal whether in-house decisions are linked to more risky projects, or to incremental rather than radical innovations. Moreover, it can indicate whether collaborations are linked to open or closed innovation processes and whether they imply complementarities or similarities among partners. On the other hand, experimental settings and longitudinal studies can allow researchers to test for risk-aversion behaviour. We believe this is a solid ground for building further research on this topic.

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Appendix

Table 3. Results of the multivariate probit model (MVP)

Theoretical Background	Hypothesis	Variable		In-House	Out-Sourcing	Hybrids
Transaction Cost Economics	H1	Total amount of R&D expenses 2004-2006	rd_tot	0.0041***	0.0040***	0.0037***
				(0.0006)	(0.0006)	(0.0005)
	H2	Being part of a holding	holding	-0.0485	0.114	0.4609
				(0.2410)	(0.2494)	(0.3130)
		Participating in a consortium	consort	-0.1314	-0.0655	0.1675
				(0.3923)	(0.4148)	(0.4497)
Strategic Management	H3	Index of market concentration±	c4	-0.0087**	0.0007	-0.0064
				(0.0044)	(0.0040)	(0.0051)
	H4	Size (number of employees)	tot_employ	-0.002	-0.0031	0.0021
				(0.0044)	(0.0052)	(0.0044)
	H5	Presence of product innovation	in_prod	0.7289***	0.4730*	0.5748**
				(0.2042)	(0.2012	(0.2573)
		Presence of process innovation	in_proc	0.4646*	0.8048***	0.6059**
				(0.2476)	(0.2422)	(0.2787)
Resource Base- view	H6	% of employees dedicated to R&D activities	per_empl_rd	-0.0056	-0.0163**	-0.0058
				(0.0056)	(0.0067)	(0.0079)
	H7	Number of skilled workers	skilledwork	-0.0117*	-0.0112	-0.0101
				(0.0066)	(0.0072)	(0.0076)
Control		Age of the company	age	-0.0006	0.0082**	0.0053
				(0.0040)	(0.0033)	(0.0044)
		Amount of investment in ICT (2006)	inv_ict	0.0036***	0.0019*	-0.0002
				(0.0009)	(0.0011)	(0.0011)
		Cooperative	coop	-0.0886	-0.5428	-0.4849
				(0.3743)	(0.4200)	(0.4785)
		Presence of export activities	export	0.2709*	0.0437	0.3001
				(0.1541)	(0.1672)	(0.1881)
		Capacity of capital accumulation in the region of location	cap_stock	-0.1573***	-0.0346	-0.1696**
				(0.0597)	(0.0545)	(0.0840)
		Innovation capacity in the region of location	in_capac	-2.6928	-0.4669	-4.0125
				(2.0688)	(2.0462)	(2.8471)
		% of public R&D investment in the region of location	pub_r_d	1.9568	0.5637	3.2669
				(1.9711)	(1.9425)	(2.6643)
		% of private R&D investment in the region of location	priv_r_d	2.5461	0.51682	3.0088
				(2.2036)	(2.1771)	(2.9022)

Table 3. *Continued*

Constant	cons	2.4085	-1.1897	2.1778
		(1.500)	(1.4130)	(2.1131)
Correlation between in-house and out-sourcing	r12	0.8135***		
		(0.0785)		
Correlation between in-house and hybrids	r13	0.8070***		
		(0.0813)		
Correlation between out-sourcing and hybrids	r23	0.6717***		
		(0.0945)		

McFadden R2 = 0.4743 Number of obs. = 347

Wald chi2(42) = 128.28 Log likelihood = -233.11711 Prob > chi2 = 0.0000

Likelihood ratio test = 0: chi2(1) = 83.4562 Prob > chi2 = 0.0000

Note. ±% turn over first 4 companies in the same sector of specialization

*** significant at 1%; ** significant at 5%; * significant at 10% level

