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Does the capital structure of firms influence their innovation strategies? Evidence from the European agri-food sector

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Abstract

The paper investigates the relationship between companies' innovation strategies and their financing strategies. Innovation strategies are distinguished as in-house and outsourcing. A bivariate probit model is implemented using cross-section data on 1,393 agri-food firms in seven EU countries. Results show that: (1) agri-food firms with a higher proportion of fixed assets are more likely to innovate, both in-house and through outsourcing. Fixed assets can be used by the firm as collateral and hence facilitate long-term loans; (2) agri-food firms that have larger sales volumes are more likely to organise their innovation processes in-house; (3) profitability and working capital increase the likelihood to observe outsourcing of innovation activities; (4) long-term leverage is negatively related to R&D outsourcing. R&D activities increase a firm's risk level.

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1 Introduction[1]

Entrepreneurship and innovation are on top of the policy agenda (Hughes, 2001). Firms are increasingly forced to actively decide on their organizational boundaries to innovate, either through in-house innovation activities or by outsourcing (part of) the innovation process (Materia et al, 2014). The decision how to innovate is crucially related to the decision about how to finance these activities and how to gain from them. Most of the empirical evidence on the relationship between innovation strategies and financial structure of firms is based on the traditional framework to analyze capital investment decisions, which assumes that the direction of causality runs from finance to innovation (Bartoloni, 2013). This interpretation is reinforced by the strategic relevance of forms of seed funding, such as venture capital, in stimulating technological progress. However, as Bartoloni (2013) states, there is room to believe that the opposite may be the case: innovative projects can open up opportunities for specific financial instruments, which can then affect a firm's capital structure. The possible implications of this alternative interpretation could be of great interest, especially from a policy perspective, as it gives an indication to decision makers about how to stimulate technological progress.

Although theories of capital structure or financial behavior tend not to focus directly on technological characteristics, they can suggest reasons why more innovative firms may favor particular sources of finance and not others (Aghion et al., 2004). Some researchers emphasize the importance of the costs of bankruptcy (Bartoloni, 2013). These costs are likely to be low for firms with a high proportion of tangible capital in total assets (e.g., property and equipment associated with generally applicable technologies). On the other hand, innovating firms with a high proportion of intangible assets (e.g., in the form of knowledge and reputation) and with more specialized equipment are likely to have high bankruptcy costs. The risk of bankruptcy may also be higher for a given level of debt. As a result, more innovative firms are likely to be less reliant on debt finance, to minimize expected bankruptcy costs (Bartoloni, 2013).

Another approach emphasizes agency costs and informational asymmetries between investors and managers of the firm. Myers and Majluf (1984) point to dilution costs of issuing outside equity when managers are better informed than outside investors about the firm's financial prospects (Bartoloni, 2013). More specifically, by selling equity to outside investors,

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the firm's current owners may signal that its future prospects are less than excellent, otherwise they would have chosen instead to remain the full residual claimant on the firm's revenues (e.g., by issuing debt, rather than equity). This signaling problem leads to new share issues being underpriced, which imposes a dilution cost on the firm's initial owners (Bartoloni, 2013).

The present article starts from a literature review on the interrelation between innovation strategies and financial structure of firms in the agri-food sector in Europe. The originality of the contribution of this article to the existing literature stems from three aspects. First, the focus of this study will be on small and medium size companies (SMEs) operating in the agri-food sector. While some authors claim that innovation activities in the agri-food sector are dominated by multinational food companies (Alfranca et al., 2004), the sector itself is dominated by SMEs. In light of increased innovation pressure, it will be especially relevant to see how these SMEs financially support innovation. Moreover, the agri-food sector has received little attention in the literature, which mostly analyses manufacturing companies. Second, the literature on firms' decisions to use external or internal resources to innovate has generally ignored the potential interrelation with the financial structure of the firms. The current study will explicitly assess the interrelation between these strategies.

Finally, most of the previous research on innovation strategies in the agri-food sector is based on case studies or on small samples of firms (Triguero et al., 2013). This study will use a very informative dataset resulting from the combination of two databases covering several European countries, EFIGE and AMADEUS. The EU-EFIGE Bruegel-UniCredit dataset consists of a representative sample (at country level) of around 15,000 surveyed firms in seven European countries (Austria, France, Germany, Hungary, Italy, Spain and United Kingdom). The sub-sample that is employed in the current study contains around 1,400 agri-food firms. Data were collected in 2010, covering the years 2007 to 2009. AMADEUS, a dataset developed by Bureau Van Dijk, contains panel data (from 2001 to 2009) of financial figures of the same companies analyzed in EFIGE.

The paper is structured as follows. The next section will present the conceptual framework and focuses on the central contributions of the main literature on the interrelation between innovation strategies and financial structure of firms (section 2). Section 3 presents the data, the variables, and the research methodology. Section 4 discusses the results. Finally, we present the discussion and conclusions in section 5, which also provides policy recommendations.

2 Innovation and financial structure of companies: insights from the literature

Papers estimating the probability that a firm undertakes innovative activities often ignore the firm's financing conditions (Aghion et al., 2004; Savignac, 2006). They identify determinants of the choice to innovate mainly in firms' specific features (e.g., age, size, organizational settings), in environmental features ("demand pull") and in technological opportunities ("technological push"). On the other side, the empirical literature on capital structure often includes information on R&D activities as control variables, without focusing on the financial

behavior of innovating firms. Moreover, there is relatively little empirical evidence from outside the United States (Aghion et al., 2004).

We summarize the literature on the relationship between innovation activities and financial indicators as a starting point for our empirical investigation. Some authors analyze financing constraints as a source of underinvestment in R&D (Czarnitzki 2005, Savignac, 2006; Gorodnichenko, Schnitzer, 2013). They use firms' cash-flows or past profitability as proxies for financial constraints (see Bond et al. 1999, Harris et al. 2003). Savignac (2006) finds that the existence of financial constraints significantly reduces the likelihood that a firm will undertake innovative projects. Moreover, this likelihood differs across industries, decreases with firm size, and it increases with market share and with the importance of the technology push. The author also finds that the ex-ante financing structure and economic performance of firms can explain the decision to innovate. Gorodnichenko and Schitzer (2013) find that innovative activities of firms are negatively and strongly affected by financial frictions. Furthermore, domestically owned firms innovate less and are more likely to be negatively affected (in their innovation activities) by financial constraints than are foreign owned firms. Among the private domestically owned firms they also find that smaller and younger firms are more negatively affected than larger and older firms are. Finally, they document a strong negative correlation between financial frictions measured at the firm level and macroeconomic measures of productivity at country level, supporting their hypothesis that financial frictions constitute a microeconomic mechanism that may restrain macroeconomic productivity and growth by adversely affecting innovation (Gorodnichenko and Schitzer, 2013).

Indicators of internal finance have also been used to explain innovative behavior of firms. Models of moral hazard and adverse selection in debt and equity markets help to explain that the rate at which small, growing firms acquire capital, including for R&D, is determined by their access to internal finance (Himmelberg and Petersen, 1994; Myers and Majluf, 1984; Savignon, 2006). Aghion et al (2004) analyze how firms fund R&D and innovation activities, for example through debts or equity (). Himmelberg and Petersen (1994) find a significant relationship between R&D and internal finance for small firms in high-tech industries in the US. Mulkay et al. (2001) obtain similar results for French and US firms. They also find that cash flow has a much larger impact on R&D investment for US firms than for the French ones. Harhoff (1998), instead, finds a weak but significant cash flow effect on R&D in German firms. However, Kaplan and Zingales (1997, 2000) show that investment cash-flow sensitivity should not always be interpreted as the existence of financial constraints (Savignac, 2006). Cash flow provides information about future investment opportunities; thus, investment cash-flow sensitivity may equally occur because firms are sensitive to demand signals.

As reported in Aghion et al. (2004), Kaplan and Strömberg (2000) provide interesting evidence of the nature of financial contracts in high-tech firms, suggesting that venture capital contracts are consistent with the predictions of the control rights theory. According to this theory, the lower the amount of tangible assets inside a firm, the more outside investors will insist on having control rights over the firm's decisions in order to satisfy their ex ante participation

constraint[2] (Aghion, 2004, p. 279). Carlin and Mayer (1999) also point to regularities in the relationship between a firm's financing mode and its type of productive activities.

Furthermore, Aghion et al. (2004) find that firms with both high R&D intensity (measured as the ratio of R&D over sales), and those with zero R&D, tend to use less debt finance than firms do with positive but less intensive R&D activity. Firm size has a significant positive effect on gearing[3], and a significant negative effect on profitability, while neither factors are highly correlated with the R&D variables used. The authors also find that an increase in R&D intensity is associated with a lower debt over assets ratio; reliance on equity finance tends to increase with R&D intensity among firms that report R&D, although this also tends to be higher for firms that report no R&D compared to firms with positive but low R&D expenditures. These results show that firms reporting R&D are likely to borrow a smaller proportion of their total debt from banks, and the share of bank debt in total debt tends to fall further as R&D intensity increases. Conversely, the share of unsecured debt tends to be higher for firms that report R&D, and tends to rise further as R&D intensity increases, although the latter result is only weakly significant).

3 Data, variable definitions and empirical methodology

The empirical analysis exploits two datasets, EFIGE and AMADEUS. The first is a database collected within the EFIGE project supported by the Directorate General Research of the European Commission through its seventh Framework Program and coordinated by Bruegel. The dataset has several unique features. First, in order to be representative of the manufacturing structure of the seven countries covered (Austria, France, Germany, Hungary, Italy, Spain, United Kingdom), it is stratified by industry, region and firm size structure. Second, data are fully comparable across countries, since EFIGE derives from responses to the same questionnaire administered over the same time span (January to May 2010). Finally, for the first time in Europe, it combines quantitative and qualitative information on firms' characteristics and activities, for numerous items split into six sections (proprietary structure of the firm; structure of the workforce; investment, technological innovation and R&D; internationalization; finance; market and pricing) (Materia et al., 2014). Most of the questions refer to 2008, some ask for information related to 2009 and years prior to 2008 in order to obtain a picture of the effects of the crisis as well as the dynamic evolution of firm activities (Altomonte et al., 2013). Data are cross-sectional and have the advantage of being neither focused on nor limited to innovative firms, which could have led to selection bias.

AMADEUS contains comprehensive financial information on private companies across Europe, covering both Western and Eastern Europe. AMADEUS is a product of ORBIS, a dataset

[2] Firms will try first to fund investments from retained earnings to relax the participation constraint of outside investors; but as more investment funds are required, firms will use debt financing. It is only when the project becomes sufficiently large and/or when assets become intangible that firms will allocate more extensive control rights to outside investors by issuing new equity (Aghion, 2004).

[3] Gearing is the level of a company's debt related to its equity capital, usually expressed in percentage terms. It is a measure of a company's financial leverage and shows the extent to which its operations are funded by lenders versus shareholders. The term "gearing" also refers to the ratio between a company's stock price and the price of its warrants. A number of ratios can measure gearing: the debt-to-equity ratio, equity ratio and debt-service ratio. The appropriate level of gearing for a company depends on the sector, as well as the degree of leverage employed by the company's peers.

containing comprehensive information on companies worldwide. Bureau van Dijk, a company with expertise in company information, develops ORBIS. Their product range includes databases of company information and business intelligence for individual countries, regions and the world[4]. For the analyses run in this article, Bruegel has provided the authors with an on-purpose version of AMADEUS under a formal agreement. It contains details about the corporate structure of the companies, in particular balance sheet data and profit and loss account data: it provides also some descriptive information such as the date of incorporation, the economic sector, the number of subsidiaries, the dimension in terms of employees.

The version of AMADEUS used for the present analysis is a panel dataset for the years 2001 to 2009. This dataset is merged with EFIGE, resulting in a unique comprehensive dataset tracing the trends in innovation activities and financial structure of the same companies involved.

For the analysis in this paper, 1,393 firms have been selected as representative of the European agri-food manufacturing sector according to the Statistical classification of economic activities in the European Community (NACE 2). Almost 33% (459) of the sampled firms is based in Spain, 24% (330) in Germany, 17% (238) in Italy and 15% (212) in France. The majority of firms in the sample (86%, 1199 firms) is active in the manufacturing of food products. Almost 25% of firms (339) is involved in the manufacturing of bakery and farinaceous products, 327 firms (24%) is involved in the processing and preserving of meat and in the production of meat products, and 320 firms (9%) in the processing and preserving of fruit and vegetables. The remaining 14% of the sample (194 firms) are manufacturers of beverages. Firms with less than 50 employees dominate the food sector in Europe, with only 8% of the sample reporting more than 250 employees[5].

In terms of turnover, 38% of the sample (524 firms) declares a turnover between two and 10 millions of euro, while 15% (215) declares a turnover of less than 1 million and only 2% (29) reports a turnover in 2008 greater than 250 million euro. In terms of the legal form, 64% (892) of the sampled firms are limited liability corporations.

Considering the innovation features of the surveyed food firms, an analysis of the data confirms the low innovation intensity of the agri-food sector observed by other authors. Almost 28% of the sample (389 firms) declares that they did not introduce any process or product innovation and they did not carry out any R&D activity in the period 2007-2009. These firms are small and medium firms (less than 250 employees), almost 76% (294) is family owned, 69% (253) are limited liability corporations and more than 11% of the 389 firms belongs to a larger group of firms. Hungary presents the highest percentage of non-innovative firms (37%), followed by Germany (33%) France (29%) and Italy (28%). None of these firms declared any investments in R&D and almost 14% of them (54) did not invest any percentage of their turnover in plants, machines, equipment and ICT in the period 2007-2009.

In terms of efforts for R&D activities, almost 40% of all firms in the sample (556) declared to have invested a percentage of their turnover in R&D in the period 2007-2009. The remaining firms (814) declared they did not undertake any R&D activity, however, almost 89% of them (724) invested in the same period a percentage of their turnover in plants, machines,

[4] http://www.bvdinfo.com/en-gb/home
[5] For more details, Materia et al. (2014).

equipment and ICT; 38% (275) of them declared they had carried out some product innovations, 32% (234) carried out process innovations.

Table 1 illustrates the main descriptive statistics of the general financial indicators we adopt in our sample.

Table 1: General financial indicators (in thousand euros)

Financial Indicators	Mean	Std. Dev.	Min	Median	Max
Current assets	7796.28	28300.35	10.58	1950.63	398900.30
Fixed assets	6917.68	33647.75	2.01	1247.65	670471.00
Total assets	14699.14	58944.65	36.03	3594.71	1064411.00
Current liabilities	6790.25	25109.00	0	1383.67	373148.30
Long-term liabilities	2579.67	10934.81	0	329.42	177727.30
Shareholders' funds	5071.86	22793.41	-15953.15	997.61	371348.70
Sales	19189.42	67168.83	144.00	4018.89	1090236.00
Net profit/loss	484.93	5036.36	-9549.33	36.91	131688.00

Source: Authors elaborations of EFIGE-AMADEUS data.

As the table shows, the majority of firms in our sample have a larger proportion of current assets in total assets than fixed assets. The sample includes firms with total assets in a range of between 36 thousand euros and more than 1 billion euros. Some firms have no current liabilities and some have no long-term liabilities. The sales range also varies dramatically between 144 thousand euros and almost 1.1 billion euros.

3.1 Variables for the empirical model

Dependent variables

The set of data considered allows us to define two dependent variables for our analysis. The first is INHOUSE and refers to firms that declared to have undertaken internal activities of research and development, meaning that they realized research activities in their laboratories and they appropriated the results of their research. INHOUSE takes the value of 1 if the firms claimed to have performed R&D activities only internally in 2007-2009, and 0 otherwise.

The second dependent variable is OUTSOURCING and represents all the research resources acquired from outside the firm. The variable was constructed based on the statement of the firms surveyed that they have acquired R&D from external sources. OUTSOURCING takes the value 1 if firms declared efforts to buy and outsource R&D activities for which internal resources were not sufficient.

Independent variables

The independent variable asset tangibility (AT) is the ratio of a firm's fixed assets to total assets. The AT indicator is commonly used by scholars to explain the leverage ratio (Booth et al, 2001; Graham & Harvey, 2001; Harris & Raviv, 1991), namely a financial measurement looking at how much capital comes in the form of debt (loans). Moreover, AT indicates the

available proportion of total assets a firm implementing R&D can use as collateral. The hypothesis in this paper is therefore that AT will show a positive correlation with both the dependent variables, innovation in-house and innovation through outsourcing.

Hypothesis 1. Asset tangibility of a firm positively influences both the decisions to innovate through internal R&D resources and external ones (outsourcing).

Profitability (PROF) is commonly used as a proxy in research related to the capital or financial structure of firms (Booth et al, 2001; Graham & Harvey, 2001; Rajan & Zingales, 1995). We calculate PROF as return on shareholders' funds. The indicator used is the return on equity (ROE). This is one of the most important ratios to consider in judging the profitability of a company. It represents how much a firm earns for each euro invested in it by a shareholder. Formally, this indicator measures the efficiency with which the management uses the available resources of a firm. A higher indicator reflects a higher return on shareholders' investment. The hypothesis in this paper is that the higher the profitability of a firm, the more it can attract external resources (debt and equity) to finance its activities, thus undertake the outsourcing R&D.

Hypothesis 2. A higher profitability of firms signals a higher probability of outsourcing R&D.

Working capital (WC) is included in the model to get a better understanding about the effect of the financial deficit on R&D processes (Shyam-Sunder L. & Myers S.C. 1999; Graham & Harvey, 2001). Based on the existing data, we measure firms' WC as the natural logarithm of the difference between current assets (total assets minus fixed assets) and current liabilities. It indicates the available liquid resources that a firm can afford to spend after covering its current liabilities. The hypothesis here is that the more WC a firm has, the more it can spend on R&D.

Hypothesis 3. More working capital positively influences the probability that the firm invests more in R&D.

Finally, we include long-term leverage (LEVLT) in the model, which is calculated as long-term liabilities divided by total assets. R&D activities are associated with higher risk levels. Moreover, firms performing R&D tend to use more debt than firms without R&D activities do (Bertroni, 2013). We assume here that a higher level of leverage has a negative effect on R&D outsourcing: when a firm already has a high proportion of debts, it becomes even more risky to invest in R&D.

Hypothesis 4. A higher level of leverage has a negative effect on R&D in general.

Table 2 summarizes the hypotheses.

Control variables

As a control variable, we use the firm's size. We measure size (SIZE) of a firm as the natural logarithm of its sales. Size of the company is considered as one of the most crucial proxies in explaining R&D activity, although its role is quite a controversial issue in the literature (Avermaete et al., 2003; Traill and Meulenberg, 2002). In general, large firms have greater financial resources and more highly qualified personnel to innovate internally, while small firms are more likely to engage in less risky activities and to buy or outsource innovation (Cruz-Cázares et al., 2013; Love and Roper, 2001). Empirical evidence, however, is not clear-cut. Some studies have found that large firms opt more for in-house innovation

strategies to take advantage of the economies of scale generated by internal R&D, marketing and production activities (Stock et al., 2002; Tsai, 2001). Other studies have reached opposite conclusions (Love and Roper, 2001). Some studies (Veugelers and Cassiman, 1999) have also found that small firms prefer to restrict their R&D strategy to either make or buy, while large firms usually combine both strategies simultaneously, stressing the complementarity of the two innovation strategies (Cruz-Cázares et al., 2013).

Table 2: Hypotheses tested, variables and description

Hypotheses tested	Variables	Description
Hypothesis 1. Asset tangibility of a firm positively influences both the decisions to innovate through internal R&D resources and external ones (outsourcing)	AT	Ratio of a firm's fixed assets to total assets.
Hypothesis 2. A higher profitability of the firms signals a likely higher outsourcing R&D	PROF	Return on equity
Hypothesis 3. A higher working capital positively influences the probability that the firms invests more in R&D	WC	Natural logarithm of the difference between current assets and current liabilities
Hypothesis 4. A higher level of leverage has a negative effect on R&D in general.	LTLEV	Long-term liabilities divided by total asset

Source: Author's presentation.

3.2 Empirical methodology

A commonly 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 or outsourcing) 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 firm j to choose an innovation strategy s can be written as follow:

$$Y_{sj}^{*} = X_j'\beta_s + \varepsilon_{sj} \quad \forall s \in S \tag{1}$$

$$Y_{sj} = 1 \; if \; Y_{sj}^{*} > 0 \quad \forall s \in S \tag{2}$$

$$Y_{sj} = 0 \; otherwise$$

where Y_{sj}^{*} is the unobservable value of the strategy s for firm j (latent variable), $Y_{sj}$is the observable strategy choice, for s=1 in case of in-house strategy and s=2 in case of outsourcing strategy. X_j' is the vector of explanatory variables, as defined in section 4.2, for firm j, β_j a vector of coefficients for strategy s and ε_{sj}a vector of unobservable characteristics related to firm j and strategy s. We can derive the probability that strategy s is chosen by firm j (γ_{sj}) as a function of the potential explanatory variables:

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

where F denotes the distribution function if the unobservable characteristics ε_{sj}. Different econometric strategies can be implemented accordingly to the nature of the strategic choice analysed and the distributional form it is assumed for F (Verbeek, 2004). A relatively common approach is to use separate logit/probit models to depict the basic binary choice of (in our case) innovate through in-house or outsourcing strategies. This would lead to a system of (two) equations. The implicit assumption is that the probability of innovating in-house is independent from the probability of outsourcing. However, there is a good chance that the firm likelihood to innovate in house is conditional to the decision whether to outsource innovation. In other word, these decisions are likely to be interrelated. The usual alternative would be to estimate a bivariate probit model. For each choice (in-house or outsourcing), a probit model is estimated and it is assumed that the error terms for the two equations are correlated. The bivariate probit model enables us to model the decisions to choose more than one strategy 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 two equation model (one for s=1and the other for s=2) is featured by correlated disturbances, which (due to identification reasons) are assumed to follow a normal distribution (variance is normalized to unity). That is for each j_{th} firm:

$$E[\varepsilon_{1j}] = E[\varepsilon_{2j}] = 0 \quad (4)$$

$$cov[\varepsilon_{1j}, \varepsilon_{2j}] = \rho = \{\rho_{12}\}$$

$$var[\varepsilon_{1j}] = var[\varepsilon_{2j}] = 1$$

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: $\{\varepsilon_1, \varepsilon_2\} = \phi_2(0,0,1,1,\rho)$. 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 choosing in-house and outsourcing strategies at the same time ($Y_{1j} = Y_{2j} = 1$) would be:

$$\gamma_{sj} = P(Y_{1j} = 1, Y_{2j} = 1) = \int_{-\infty}^{\varepsilon_{1j}} \int_{-\infty}^{\varepsilon_{2j}} \phi_2(X_j'\beta_1, X_j'\beta_2, \rho) d\varepsilon_{1j} d\varepsilon_{2j} = \Phi_2(X_j'\beta_1, X_j'\beta_2) \quad (5)$$

In this model the log-likelihood is then a sum across the four possible strategies variables (that is, four possible combinations of innovate ($Y_{1j} = Y_{2j} = 1$) and non-innovate ($Y_{1j} = Y_{2j} = 0$) times their associated probabilities (Greene, 2008). These probabilities may be drawn from (5) as well. The most relevant coefficients estimated in the model are β_1, β_2 and $\rho(\rho_{12})$. The latter, if significantly different from zero, will evaluate to which extent each pair of decisions are interrelated.

4 Results

4.1 Descriptive statistics

Table 3 presents the descriptive statistics of the variables used in the estimates. On average, the firms in our sample have 42% of fixed assets in total assets, with a maximum of 95%. The average profitability ratio is 5%. Eighteen per cent of total assets are financed by long-term liabilities.

Table 3: Descriptive statistics

Financial Indicators	Mean	Std. Dev.	Min	Median	Max
Asset tangibility	0.42	0.22	0	0.40	0.95
Size	8.48	1.44	4.97	8.30	13.90
Profitability	0.05	1.43	-24.16	0.05	16.20
Working capital	6.48	1.77	-0.53	6.59	12.57
Long-term leverage	0.18	0.26	0	0.10	3.45

Source: Authors elaborations of EFIGE-AMADEUS data.

Table 4 reports the correlation matrix. As expected from earlier studies, significant correlation coefficients are observed between different financial indicators.

Table 4: Correlation matrix (rounded to the nearest hundredths)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) R&D-in-house	1						
(2) R&D-outsourcing	0.16***	1					
(3) Asset tangibility	0.06*	0.05	1				
(4) Size	0.26***	0.11***	-0.20***	1			
(5) Profitability	0.01	-0.02	0.01	-0.06*	1		
(6) Working capital	0.20***	0.12***	-0.23***	0.66***	-0.03	1	
(7) Long-term leverage	-0.03	-0.05	0.20***	-0.17***	0.04	-0.13***	1

* p<0.1; ** p<0.05; *** p<0.01

Source: Authors' elaborations of EFIGE-AMADEUS data.

4.2 Regression results

Different model estimates have been run[6]. The results presented in this section refer to the pooled model. Table 5 shows the results of the bivariate probit model.

[6] We inserted in the model as a control also the age of the firms, but since the coefficient associated to it was not significant in any of the specifications, we did not report it in the final model.

Table 5: Results of the bivariate probit model

	In-house		
	Coefficient	Robust Std. Err.	P>z
AT	0.771	0.454	0.090
PROF	-0.097	0.105	0.355
WC	0.066	0.050	0.190
LEVLT	0.104	0.608	0.864
Control variables			
SIZE	0.208	0.067	0.002
Constant	-2.838	0.522	0.000
	Outsourcing		
	Coefficient	Robust Std. Err.	P>z
AT	1.185	0.518	0.022
PROF	0.216	0.050	0.000
WC	0.153	0.074	0.039
LEVLT	-1.436	0.775	0.064
Control variables			
SIZE	-0.042	0.076	0.581
Constant	-2.184	0.578	0.000
n. observation			342
Wald chi2(10)			52.65
Loglikelihood			-327.197
Prob > chi2			0.000

Source: Authors' elaborations of EFIGE-AMADEUS data

We find support for Hypothesis 1. It would appear that a higher level of AT positively effects R&D activity: AT coefficients are positive and statistically significant for both R&D in-house and R&D outsourcing. As expected, the coefficient is larger for the firms outsourcing R&D. The results also illustrate that PROF encourages R&D outsourcing. Furthermore, consistent with Hypothesis 3, the model shows that higher WC increases R&D in general, but the coefficient is significant for R&D outsourcing only. In support of Hypothesis 4, we find a significant and negative influence of long-term borrowings on attracting external resources for R&D. Finally, the control variable (SIZE) demonstrates that firms with a larger volume of sales tend to innovate in-house.

5 Discussion and concluding remarks

The paper has investigated the relationship between companies' innovation strategies and their financing strategies. This relationship has been analysed for a sample of 1,393 firms that are representative of the European agri-food manufacturing sector. The sample was derived from the EFIGE database and covers the agri-food sector in seven EU countries: Austria, France, Germany, Hungary, Italy, Spain, and United Kingdom. The following conclusions were drawn based on the econometric analysis:

- Innovation activities, both in-house and through outsourcing, are observed more in agri-food firms with a higher proportion of fixed assets in total assets. So-called asset tangibility may result from the fixed assets that are necessary for in-house innovation activities. Moreover, fixed assets can also be used by the firm as collateral and hence facilitate long-term loans;
- Agri-food firms that have larger sales volumes are more likely to organize their innovation processes in-house. Innovation outsourcing is less likely to be observed;
- Profitability and working capital – or the available liquid resources of a firm – both increase the likelihood to observe outsourcing of innovation activities, while no effect was found on the level of in-house innovation;
- Long-term leverage, which is calculated as long-term liabilities divided by total assets, is negatively related to R&D outsourcing. R&D activities increase a firm's risk level. For agri-food firms with already high levels of debt, investments in R&D become even more risky.

These results show the relevance of financial performance and strategies for innovation activities in EU agri-food firms. The size of the firm – in terms of sales volumes but also in total fixed assets – is the key determinant of in-house innovation activities; while a high level of profits and working capital – are drivers of outsourcing innovations. The riskiness of innovation activities remains a possible deterrent for innovation, especially for agri-food firms that are already highly indebted.

In terms of recommendations for decision makers, these results suggest that policymakers that are interested in stimulating innovations in the EU agri-food firms should be aware of the clear interrelation between financial performance and strategies for innovation activities. Moreover, innovation activities are observed most in agri-food firms with high proportions of fixed assets, while firms with already high debt levels are less likely to innovate. These observations show the importance of firms' financial structure and access to financial resources to allow for innovations. From a policy perspective, this leads to arguments in favor of innovation investment funds.

There are several extensions to this line of research that we intend to pursue. One important development will be to use other indicators of (1) the internal financial structure of firms; (2) the extent of firms' innovative activities than simply using their decision to invest in internal R&D or outsource innovation. It will be useful to confirm our results using alternative technological and financial indicators. Moreover, the model could be extended to consider specific country- and sector- effects. Other independent variables could be added to take into account potential influences from human capital and knowledge (e.g., number of employees

with a degree, number of employees involved in R&D activities etc.); other control variables could be tested too reflecting the socio-economic domain in which the firms are operating (e.g., incentives from the public sector to innovate, indicators of financial stability, etc.).

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Project information

Title:	International comparisons of product supply chains in the agri-food sectors: determinants of their competitiveness and performance on EU and international markets (COMPETE)
Funding:	Collaborative research project (small or medium-scale focused research project), FP-7-KBBE.2012.1.4-09, total EU contribution is 2,422,725 €
Duration:	01/10/2013-30/09/2015 (36 months)
Objective:	The objective of the COMPETE project is to gain a more comprehensive view on the different elements which contribute to the competitiveness of the European agri-food supply chain in order to provide better targeted and evidence based policies on the EU as well as on the domestic level. The project investigates selected determinants of competitiveness like policy interventions and the business environment, productivity in agriculture and food processing, the functioning of domestic and international markets, the choice of governance structures, and innovative activities in food processing. The research results will enable a congruent, coherent and consistent set of policy recommendations aiming at improving competitiveness of European product supply chain.
Coordinator:	IAMO, Germany, Prof. Heinrich Hockmann
Consortium:	16 Partners from 10 European countries. COMPETE brings together academics, trade bodies, NGOs, agricultural co-operative, industry representative advisory services. In addition, the project is supported by the group of societal actors, incorporating farmer, food processing and consumer associations, providing in-depth knowledge on the agri-food sector and speeding up the achievement of the project goals.
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COMPETE
International comparison of product supply chains in the agro-food sector

SEVENTH FRAMEWORK PROGRAMME

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