Bivariate probit models for analysing how "knowledge" effects innovation and performance in small- and medium-sized firms

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Abstract

This paper examines the determinants of innovation and its effects on small- and medium-sized firms It use the data from the OPIS databank, which provided a survey on a representative sample of firms from a province of the Southern Italy. The final goal is to understand whether small- and medium-sized firms can develop a competitive advantage by using their innovative capabilities, regardless of the sectoral and size limits. We underline that the main factor influencing the likelihood of innovation is knowledge, which is acquired through different ways (e.g., the level of education, training, and networks). With regard to our econometric methodology, we construct a bivariate model to estimate the probability of increased sales conditionated to the probability of innovation controlling for the correlation between these two outcomes. We found that the knowledge positively influence the probability of innovation instead the competitive advantage is not directly and positively affected by our hypothesis of high level of knowledge.

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1. Introduction

Innovation has become an important concept in economic theory and previous researchers have focused on the determinants and the effects of innovation, which are usually expected to generate a competitive advantage in the innovating firms and to boost the dynamism of the sectors to which the firms belong (Nelson, Winter 1982; Dosi 1988; Freeman and Soete 1987). Driven by the same interest of the relevant literature, in this paper we examine the cause and the effects of innovation, but while the dominant literature links innovation to technological economic sectors and to bigger firms, we concentrate the analysis on traditional and small- and medium-sized firms (SMEs). To provide evidence on this topic we embrace a wider definition of innovation and we consider new determinants most relevant to the economic system characterized by SMEs.

At the same time, innovation is difficult to define. Some researchers have tried to elaborate a taxonomy of various sectors by identifying the level of the innovation that generates new products or production processes (Pavitt 1984, p. 344; Patel, Pavitt 1995). Many scholars use this taxonomy and strictly link the innovation to the sector without focusing on the innovation activities of the firm. Innovation is often related to technological change and to Research and Development (R&D) activities (OECD 1997)

Nevertheless, innovation is not always linked to technology of the sector because innovation may affect the organisational structure of the firm. Although the traditional definition of innovation (i.e., innovation in terms of new products or production processes) is still important, we adopted a broader definition (OECD 1997) of innovation considering also managerial and organisational innovations.

Thus, we can define the word "innovation" not only by its semantics (i.e., innovation represents something new to a firm) but also by its effects on a firm as a whole. That is, innovation also generates an advantage for the firm. According to our approach, innovation consists of new ideas that create an advantage for the firm.

Prior scholars have noted that the origins of innovation lie in a firm's ability to acquire and manage new knowledge (Cohen, Levinthal 1989; Waarts et al. 2002). Thus, not only R&D activities but also other sources of knowledge within the firm can generate innovation. These sources can be both internal and external. Additionally, they may rely on human capital and networks.

Can a firm be innovative even if it is not the appropriate size (i.e., the firm is small- or medium-sized) and does not compete in a dynamic, innovative sector?

In this case, innovation may be linked to the manner in which the firms are organised, interact among themselves and internally circulate ideas and information. We considered certain characteristics of the management or the entrepreneur as important[1]. At the same time, we looked at each firm's ability to exploit others source of knowledge.

This new definition of innovation allows us to broaden the sources of innovation and overcome the limitations in R&D expenditures and other traditional indicators that have hindered previous efforts to investigate the innovation potential of SMEs.

Another frequent discussion point is the effects of innovation. Many scholars have attempted to investigate the effects of innovation and the role of technology within firms. The results of their studies are generally positive (Griliches 1995; Hall, Mairesse 1995; Loof, Heshmati 2001).

Then the principal aim of our paper was to shed light on the causes and effects of innovation on small- and medium-sized firms (SMEs). We were able to make these investigations thanks to an *ad hoc* survey that investigated small and medium firms from the province of Salerno in Southern Italy (OPIS[2] database.) Specifically, we utilised a survey on a sample of 469 manufacturing firms from the province of Salerno (Italy) and interviewed during the 1998/1999[3]. The sample is representative at both the territorial and sectoral level[4]. The questionnaire has nine sections and approximately 200 questions that cover all aspects of each firm (Coppola, Farace, Giordano, Mazzotta, 1999)

We focus on factors other than those traditional elements, such as dimension and Pavitt sector, that previous scholars have already shown to have positive and significant impacts on innovation (Pavitt 1984; Griliches 1995). We seek to underscore the weights of other elements, such as the entrepreneur's level of education and previous experiences, the employees' involvement in the strategic decisions of the firm and/or the networks that

[1] Because we often analyse small- and medium-sized firms, we do not distinguish between management and ownership, as the manager and the owner may be the same person.

[2] The OPIS project (Permanent Observatory on Enterprises in the province of Salerno) consists of the implementation and empirical application of a statistical methodology used to analyse an economic system characterized mainly by the presence of small- and medium-sized enterprises (SMEs) in a province in Southern Italy.

[3] We exclude the firms which created innovations more than six years ago.

[4] The OPIS dataset adopts a weighting procedure that relates the sample of the interviewed firms to the entire population (i.e., the firms from the province of Salerno). The weight in OPIS indicates the inverse of the probability that the observation is sampled.

characterise the relationships between small- and medium-sized firms. We argue that these elements can play an important role in the introduction and effectiveness of innovation.

The paper is organised as follows. Section 2 discusses our theoretical framework with regard to the causes and the effects of innovation. Section 3 follows with a description of the model that we propose to analyse innovation in SMEs. The data and the independent variables used in our empirical analysis are described in Section 4. In Section 5, we present and discuss the empirical outcomes of the econometric estimates. Finally, Section 6 concludes the paper by summarising the main findings.

2. Definition and relevance of innovation

2.1 The definition of innovation

Since Schumpeter (1934) the economic literature has long recognised the role of innovation as one of the main elements influencing firm competitiveness. However, the literature still lacks a consensus on the reasons why innovation enables firms to achieve better performances.

One of the primary problems is the definition of innovation. Schumpeter defined five types of innovation[5]. More recently, many studies have focused on two of them: product and process. Based on this approach, scholars have related innovation to a firm's adoption of new technology such that R&D activities within firms are now viewed as one of the main sources of innovation.

One of the most commonly adopted definitions of innovation is the definition provided by the OECD (1997). The Oslo Manual defines two types of innovation: product and process. Product innovation occurs if a firm introduces a new or improved product that differs from the previous generations of the product. Process innovation can result in "*new or significantly improved production methods, including methods of product delivery*" (OECD 1997 p.49).

The OECD's approach defines innovation as "something new or an improvement that applies to a firm". Innovation remains complex because even though it "is studied in many

[5] The five types of Schumpeter's innovation are the following: new product, new process, new market, new source of raw materials, and a change in the industrial organization (Schumpeter 1934).

disciplines and has been defined from many perspectives" (Damanpour, Schneider 2006, p. 216), a consensual definition of innovation still does not exist (Baregheh et al. 2009). Because "the term innovation is notoriously ambiguous and lacks either a single definition or measure" (Adams et al. 2006, p. 22) and because many definitions exist, we approach this problem from a more general perspective and define innovation as "new ideas that are introduced in the firm in many ways and that allow the firm to get an advantage" (Adams et al. 2006, p. 22).

The general definition has some interesting implications for the role of technology because the OECD addresses Technological Product and Process (TPP) innovations. Because innovation is adopted at the firm level, innovation should be studied and analysed at that level. In fact, innovation is often analysed from a technological point of view, and technology is widely regarded as the major source of innovation[6].

Therefore, the aim of R&D activity is to introduce new products and/or new processes by using new or better technologies. Firms often patent new products to create a competitive advantage at least for the period of time during which the patent is in effect[7].

However, the difference between product and process innovations can be narrow because sometimes one sector may identify an innovation as a new product, whereas another sector may identify the same innovation as a new process.

Additionally, innovations often assume different forms depending on the size of the innovating firms. Bigger firms usually have more financial resources, a better codified organisation and a R&D department/function. Oftentimes, large firms use their market power to increase the advantages of their superior innovative capacities. At the same time, these firms innovate to maintain and/or increase their market power. As a result, the outcome of an innovation activity in a large firm is usually a product innovation (Mansfield 1981; Pavitt et al. 1987; Dorfman 1987).

[6] We are not discussing the importance of technology and its positive effects on innovation. Plenty of studies have addressed technology systems that generate clusters of innovations representing "natural technological trajectories" (Nelson, Winter 1977) or "technological paradigms (Dosi 1982). Other scholars have identified the cumulative advantages belonging to firms capable of continual innovation and the path dependence issues related to innovation (Rosenberg 1976; Nelson, Winter 1982).

[7] We now know that even if patents are an indicator of innovation activities, they do not have any explanatory power. Not all research activity results in a patent. Sometimes, companies prefer to not protect their inventions with a patent. Additionally, the word "invention" indicates the difference between inventions and innovations. The former can be patented but cannot become an innovation, as inventions cannot be economically exploited.

Small firms suffer from limited financial resources and an inability to diversify their risks. Consequently, these firms usually prefer to acquire technologies embodied in new machinery. For small firms, technology acquisition (TA) is the primary source of innovation, and their innovation activities usually generate process innovations (Freeman 1982, Freeman and Soete 1987; Conte, Vivarelli 2005). Thus, small firms prefer to acquire technologies that are compatible with their organisation rather than risk investing in research programs whose expected results carry a considerable risk of failure.

There are similar results when we consider innovation at the sectorial level. Firms within traditional sectors often generate process innovations by acquiring new machinery and the technologies embodied in this machinery. In high-technology sectors, the firms invest more resources into research programs and activities and frequently generate product innovations (Pavitt 1984). Because high-technology sectors are generally more dynamic, these sectors are considered more innovative than other sectors (Pavitt 1984; Nelson, Winter 1982; Freeman 1982).

Other types of innovation in addition to process and product innovations are also important. For example, organisational innovations that refer to new and improved organisational and management-related strategies are also important (OECD 1997). This broader definition of innovation, which considers aspects different from those of technological innovations, allows for a more complete definition of innovation.

Innovation should not only be seen as a product or process innovation but also as new form of organisation or a better way to manage the company. According to Fargeberg, Shrolec, Verspagen (2009), innovation may be considered a better way to do things.

Introducing new products or processes are not the only way that a firm can innovate. We also consider managerial innovation, which is a better configuration of a company's existing structure and is strictly related to an entrepreneur's level of education (Colombo, Grilli 2008; Prahalad, Hamel 1990).

Besides the problem about the definition of innovation, all types of innovation are difficult to measure, as finding a univocal set of parameters that can measure innovation or the innovative capabilities of firms is a challenging task[8]. We can use the effect(s) of innovation as a proxy for the innovation capabilities of firms because the definition of

[8] Different indicators are used to measure innovation. These measures are classified as input and output indicators. The first group (i.e., R&D expenses, R&D employees, and TA measures) measures a firm's innovative effort, whereas the second group (i.e., patents, trademarks, and others) measures the results. Both types of indicators have some limits (see OECD 1989).

innovation implies that new ideas create value for the firm. Hence, we may derive more utility from examining and evaluating the results of innovation rather than attempting to analyse innovation capabilities firsthand. The difficulty lies in correctly connecting innovations to their results. In this approach, one must design and conduct *ad hoc* surveys to investigate this relationship[9].

Despite the problematic definition of innovation and their effects, no scholars doubt the importance of innovation to firm competitiveness (Fargeberg 1996). Firms that are able to introduce new and better technologies or improve organisation and management can create a competitive advantage that results in enhanced market share or market performance.

2.2 The role of knowledge

Some scholars have underlined the importance of information related to research activities. These researchers have argued that "*R&D not only generates new information, but also enhances the firm's ability to assimilate and exploit existing information*" and that innovation depends on "*the firms' ability to identify, assimilate and exploit knowledge from the environment*" (Cohen, Levinthal 1989, p 569). R&D activities enable firms to develop this ability.

As we noted previously, a positive relationship exists between technology and innovation. In most situations, innovation is assumed to be the result of a more advanced technology. Although this assumption is generally true, such an approach captures only a part of the phenomenon, especially in those territories in which small- and medium-sized firms dominate and in which the firms specialise in traditional and, thus, less innovative industries.

Research plays a key role because it allows firms to develop a capability to manage their information such that the firms can obtain advantages from information both inside and outside the firms.

We argue that a firm's ability to obtain and exploit information not only depends on the firm's R&D activities but is also positively linked to the firm's human capital and relationships. These relationships can include the networks between a firm and its

[9] We followed this approach in this paper by using the OPIS databank (Coppola, Farace, Giordano, Mazzotta 1999). Sometimes, specific surveys are not needed if there are specific data available.

environment. This ability is important because the firm can exploit information generated by different sources and transform this information into knowledge, which is the only factor that influences innovation.

At a certain stage in a firm's lifetime, the firm's stock of knowledge becomes its absorptive capacity (Cohen, Levinthal 1989). Afterwards, the firm's R&D activities are shaped in accordance with this capacity. In this case, the firm's process of knowledge formation is based on the firm's prior acquisition of knowledge according to a cumulative process. Thus, the firm can develop an important advantage through its innovative activities. This view does not consider knowledge to be a public good (Arrow 1962; Nelson 1959) and distinguishes firms based on their "*capacity to recognise, assimilate and exploit information*" (Cohen, Levinthal 1989, p. 593).

R&D is not the firm's only source of knowledge. The factors that are critical to a firm's ability to introduce and exploit innovations are considerably different from one another. In their study, Waarts et al. (Waarts et al. 2002) analysed the characteristics of the innovation and the firms as well as the firms' internal and external environments.

More generally, a firm attempts to acquire knowledge from all possible sources. These sources may vary from one firm to another, especially if the firms' size or sectors are different.

By adopting this point of view, we can explain the innovative capacities of small- and medium-sized firms operating within traditional sectors in Italy. These firms utilise their knowledge to continually exploit innovation and thereby enhance their performances (Becattini et al. 2009).

A firm's sources of knowledge can include not only technology (e.g., R&D) but also human capital. Additionally, the firm's relationship to the environment can also serve as a source of knowledge. Knowledge can arise from both inside and outside the firm. We underline the role of networks in enabling a firm to develop new knowledge and to exploit its existing knowledge in a different and more efficient manner. For example, a firm may derive knowledge from its workers, suppliers and competitors.

3. The theoretical model

We aim to underline the impact of knowledge on a firm's efforts to develop innovations through which the firm can develop a competitive advantage. To take advantage of knowledge, firms must be able to handle different sources of knowledge while developing new ideas that can add value to the firms.

As Cohen and Levinthal (1989) note, innovation is related to knowledge. This argument implies that firms have the capacity to not only handle their existing knowledge but also acquire new knowledge.

Firms can innovate in many different ways. In addition to acquiring the technologies embodied in new machinery to generate process innovations, small firms can play a strategic role by collecting information, interpreting this information, increasing their knowledge and introducing new and better ways to do things.

Figure 1 Around here

A firm's stock of knowledge enables the development of innovations. The larger the stock of knowledge is, the higher the probability that the firm will innovate.

Defining a firm's stock of knowledge at any given period can be difficult, as knowledge can be acquired through a variety of methods. In our model, there are three main sources of knowledge within a firm (See Figure 1):

- Technology
- Human capital
- Networks

In our model, a firm acquires new knowledge or improves the existing knowledge to develop innovations. Eventually, the firm's efforts will result in a better performance.

As Cohen and Levinthal (1989) note, technology prevalently deriving from R&D is one of the most important ways through which a firm acquires knowledge. However, for small- and medium-sized firms that do not have institutional R&D functions or activities, this channel of knowledge is unavailable.

Even if we apply a more generalised model, the first source of knowledge (i.e., technology) is less important to SMEs than to large companies. In our opinion, the main sources of knowledge in SMEs are human capital and networks. In fact, human capital and networks are practically the only sources of knowledge for SMEs.

When we refer to human capital, we consider the entrepreneur's and the employees' educational levels and previous experiences. The entrepreneur's level of education and competence open his or her mind to the importance of human capital and the experiences of his or her workers, whose participation in the firm's strategy should be welcomed and encouraged. Thus, human capital is an important source of knowledge for SMEs. The role of human capital is also important because human capital leads firms to construct internal networks such that the relation between the owners and the workers is reinforced. By doing so, the firm develops greater opportunities to build its knowledge base.

Furthermore, a firm's stock of knowledge is contingent on the availability of information, which, in turn, depends on the relationships and the networks that the firm, whether big or small, has established both within the firm and with the outside world.

This approach underlines the positive role played by networks, which can be both formal and informal, in the innovation process. In the case of a big firm, these relationships

mainly exist between the firm and the scientific world (e.g., universities and research centres).

In the case of small- or medium-sized firms, the network is mainly informal and involves the firm's links to the surrounding environment. These types of networks generally produce positive externalities à la Marshall (Audretsch and Feldman 1999) and sometimes involve industrial districts (Jacobs 1969; Sforzi 1995; Becattini 1989; Becattini, Bellandi, De Propris 2009).

The networks utilised by small- and medium-sized firms have different origins and can relate to the firms' participation in consortiums and the firms' relationships with various actors, such as suppliers, buyers, and customers. A firm's links to other social and economic networks can help the firm resolve strategic issues during the innovation process.

Another important network is the network inside the firm. In some cases, the entrepreneur continually interacts with his or her employees. As a result, if these employees participate in the firm's strategic decisions, then they may enhance the firm's stock of knowledge and thereby facilitate innovation.

Based on the theoretical perspective of the paper, we focus on three groups of variables. These variables can help us identify the path to innovation for small- and medium-sized firms. Because these types of firms do not have R&D departments or workers who are specifically and exclusively interested in innovation, we had to examine other factors to determine whether the firms innovate.

Following Cohen and Levinthal (1989) and Fargeberg, Srholec, Verspagen (2009), we broaden the boundaries of innovation such that it now refers to the extent of the available information or knowledge. This knowledge allows for innovation that can provide a better way to do things. Based on this approach, we consider three types of innovation:

- product
- process
- managerial

Whereas the first two types of innovation are mainly, though not exclusively, related to technology (OECD 1997), the last type generates better combinations of existing routines,

better organisations, and better managerial activities, all of which result in a significant increase in the firm's competitiveness[10].

This approach implies that the presence of highly educated workers in a firm is a potentially important advantage[11] because these workers can generate knowledge and innovations that can be easily exploited.

Additionally, another factor that can influence the innovation process is the environment in which firms operate. According to Waarts et al. (2002), the important factors that play a key role in the innovation process are the characteristics of innovation, the characteristics of the firm, and the internal and external environments.

Thus, we have a better chance of explaining the role of innovation if we examine small- and medium-sized firms that are localised in specific areas. Marshall (1961) and Becattini and Bellandi[12] (2009) embraced this view, which proposes the study of firms within their "industrial districts".

Based on this literature and to verify our assumption, we considered three groups of variables:

1) firm-specific characteristics,

2) entrepreneur-specific characteristics,

3) network characteristics.

The first group refers to the firm and includes useful variables for keeping the effect of traditional determinants of the propensity for being innovative as: dimension of firms in number of employees; the sector; according to the ATECO classification ; the age of the firm; information related to the founder and the dynamism of the firms in terms of whether the firm sells products to the local, regional, national, or international markets or whether the firm has conducted professional training activities in the last three years.

The second group of variables allows us to define knowledge linked to the cultural background of the entrepreneur/owner. The variables in this group consist of the

[10] The survey on small- and medium-sized firms from the province of Salerno has enabled us to analyse these types of innovation and the outcomes of these innovations.

[11] This advantage becomes effective if the workers can spread their knowledge and contribute to knowledge spillover.

[12] The definition of industrial districts requires another factor in addition to the presence of small- and medium-sized firms in the given territory (Becattini 1989).

following: the entrepreneur's level of education, age, former occupation before starting the firm and number of experiences working as an entrepreneur.

The third group considers the firm's relationship to the external environment. We analyse this relationship from multiple perspectives. On the one hand, we consider whether the firm is participating in a consortium or has other relationships with other firms. On the other hand, we analyse the firm's general relationship with its surrounding environment (external networks) Besides we consider the workers' participation in the firm's strategic decision-making process. We aim to determine whether the firm has a much broader relationship with the territory in different ways, to identify the level of this relation and ascertain whether the firm can obtain new knowledge through this relation (internal networks).

Looking at the expected results of innovation, we found that innovation enhances the firms' competitiveness and, thus, induces better firm performances. We can measure the improvements in the firms' performances in many different ways, such as increased revenues, profits, market share and market power. In any case innovation and its effects are interrelated and it's impossible to deny a reciprocal correlation: the better performances of the firms depend on innovation and also the innovation activity may depends on the actual or expected performances.

4. Datasets and explanatory variables

4.1 Description of datasets

We extracted the data used in this study from the OPIS[13] database. Specifically, we utilised a survey on a sample of 469 manufacturing firms from the province of Salerno (Italy) and interviewed during the 1998/1999 with a *face to face technique*[14]. The sample is significant at both the territorial and sectoral level[15]. The questionnaire has nine sections

[13] The OPIS project (Permanent Observatory on Enterprises in the province of Salerno) consists of the implementation and empirical application of a statistical methodology used to analyse an economic system characterized mainly by the presence of small- and medium-sized enterprises (SMEs) in a province in Southern Italy.

[14] We exclude the firms who introduced innovations more than six years ago.

[15] The OPIS dataset adopts a weighting procedure that relates the sample of the interviewed firms to the entire population (i.e., the firms from the province of Salerno). The weight in OPIS indicates the inverse of the probability that the observation is sampled.

and approximately 200 questions that cover all aspects of each firm (Coppola, Farace, Giordano, Mazzotta, 1999). The first section describes the factors influencing the birth of the firm and the firm's life in general. There is also information about the firm owner's previous occupation and her/his level of education. An important section was devoted to collecting information on the type (i.e., process, product and managerial) and the timing of the firm's innovations, their effectiveness and the sources through which the firm acquires information on the innovations.

The subsequent sections analysed some managerial aspects, such as the markets from which the firms purchase and sell goods. Additionally, the survey examined each firm's number of workers, social environment, and relations with not only the local community but also other enterprises in the area (for more details, see Coppola, Farace, Giordano, Mazzotta, 1999).

One specific section of the questionnaire was called "innovation", in which we point out all of the activities, conditions and results of the firms' innovations. In addition to the traditional distinction between product and process innovations (OECD, 1997; Fagerberg at 2009), we also consider managerial innovations, which can be used as both a proxy of *learning by doing* and *learning by using*. More generally, we define a managerial innovation as a better way of doing things. These innovations are not related to technology but to superior organisational and management skills.

One must consider a non-technological innovation, such as managerial innovations, because small- and medium-sized firms usually do not have R&D functions and are often not directly involved in innovation activities. These SMEs attempt to improve upon previous processes not by using new technologies but by improving the existing elements within firms.

Nevertheless, the average size of the firms in the Province of Salerno is quite small. Their size affects their ability to consistently innovate.

Our first results show that 42.76% of the firms in our sample introduce at least one innovation. Of these innovations, the majority are process innovations (61.88%).

Table 1 here

Table 2 here

Our sample[16] is composed of 415 firms. Of these firms, 196 are innovative firms that have at least one innovation And the 43.4% of these 196 firms gains an increase of sales during the last three years. Among the firms not innovative the percentage of the firms that increase their sales is of only 26.9% (Table 3).

In the sample (Tab 4), most of all firms (i.e., more than 60 percent) operate in the traditional sector, which is dominated by suppliers according to Pavitt's taxonomy. In addition, most of the firms are founded by the actual owner, have links to the local area, produce goods for a final market, have 9 employees on average and are approximately 21 years old. Innovative firms have usually more employees than other firms.

[16] These firms are not missing with respect to the variables used in this study.

Table 3 around here

According to Table 5A, approximately 64.2% of the companies introduce at least one innovation. With respect to Pavitt's taxonomy, 56.3% of the scale-intensive firms have at least one innovation. With regard to the entrepreneur's educational level, 75.2% of the companies led by an entrepreneur with a tertiary/university degree are innovative and among the firms affiliated with a consortium 73.56% have at least one innovation.

According to Table 5B, firms with a positive performance in the market' sales was not characterized by any of the variables considered. Only among the firms that sell both semi-finished and finished products prevailing firms that have increased sales (56,0%)

Table 5 around here

When we examine the mean of the number of innovations (Table 6), we see that the science-based companies generate the highest number of innovations. In addition, we find that the higher the mean of the number of innovations, the higher the owner's educational level is.

Table 6 around here

4.2 Econometric models and explanatory variables

With regard to the econometric methodology, we study the basis for the decision to innovate and the determinants of the improvements in the firms' performances. Hence, we think that one of the determinants of innovation is the degree of faith or the entrepreneur's expectations of the potential market and at the same time the market potential depends on the firm's innovative capacity. Therefore, the best model should be one that considers the correlation between market trends and the introduction of innovations. Then we used the following econometric model:

$$FATT^* = \alpha_1 INN^* + X_1\beta_1 + e_1 \qquad [1]$$
$$INN^* = \alpha_2 FATT^* + X_2\beta_2 + e_2 \qquad [2]$$

*FATT** and *INN** are endogenous latent variables reflecting respectively the firms's propensity for increasing sales and for being innovative. *FATT** and *INN** are simultaneously determined . X_1 includes the covariates usually found as determinants of sales's increasing and X_2 includes the covariates usually found as determinants of propensity to innovate (i.e., firm characteristics, entrepreneur characteristics and network characteristics). Note the underlying latent structural variables in the two equation and not the observed binary variables. This model is identified and it can be consistently estimated with a two step methods but it's hard to interpret (Maddala, 1983). Therefore we decided to follow two alternatives strategies. The first is to estimate the reduced-form of equations [1] and [2], that is:

$$FATT = X_1\Pi_1 + u_1 \qquad [1a]$$
$$INN = X_2\Pi_2 + u_2 \qquad [2a]$$

FATT =1 if the firm's sales increase during the last three years in at least one of its sales markets and 0 otherwise.

INN =1 if the firm produces at least one innovation during the last six years and 0 otherwise.

Where X_1 and X_2 contain all the exogenous variables [17]

We estimate equations [1*a*] and [2*a*] by using standard bivariate probit techniques, as shown by the following:

$$y_j = \begin{cases} 1 \quad if \quad y_j^* > 0 \\ 0 \quad if \quad y_j^* \le 0 \end{cases}$$

where j=1, 2 and reduced–form disturbance covariance Cov $(u_1, u_2) \neq 0$. To verify whether the two outcomes are really correlated, we test the significance of ρ, which represents the correlation between the errors in the two probit models. The dependent variables are *INN* and *FATT*. [18]

In our questionnaire, we acquired information on the firms' revenues over the last three years[19] that we think a good proxy for the actual and expected performance in the market sales and the innovations introduced over the last six years[20] then we think that the

[17] We can use the same independent variables in each probit model. Additionally, we can estimate a seemingly unrelated version of the bivariate probit model by using two different independent variables. We choose this second option. We include the legal form variable in our estimated probability of innovation, but we exclude this variable from our estimated probability of increased sales.

[18] Another model may consider the potential endogeneity of the innovation variables. Instead of analysing a biunivocal relation between the two probabilities (i.e., innovation and increased sales), this model may consider the direct dependency of the probability of increased sales (FATT) on the probability of innovation (INN). The potential endogeneity of innovation could be a choice variable that is correlated with unobservables relegated to the error term. For this analysis, we used a probit model with dummy endogenous variables or a probit regression model with endogenous switching (Miranda Rabe-Hesketh, 2006). The results of this model were not convincing. This model was not stable and presents difficulties in the convergences.

[19] The revenues concern sales of both final products and intermediate commodities

[20] The question in the questionnaire is: The interviewer (entrepreneur or other managing director) may indicate up to 3 innovations (product, process or managerial) introduced during the life of the firm? For innovation we mean any change that the company introduced on use of its resources (it is important to emphasize that this definition also falls into innovation whose result was negative)

dependence of the probability to innovate on the firms' revenues is low, while is more strong the dependence of the increased sales on the introduction of innovations.

Consequently an alternative model should one that consider two equation in which the endogenous "innovation" (*INN*) variable is among the explanatory variable in the "increased sales" (*FATT*) equation. On the other hand, "increased sales" does not appear in the "innovation" equation.

Hence a recursive equation model (Maddala, 1983; Holly et al., 1998; Greene, 2003) is obtained. The "innovation" equation is modelled as reduced-form equation instead the "increased sales" is a structural equation with the innovation variable as explanatory variable.

$$FATT^{*} = \alpha_1 INN + X_1\beta_1 + e_1 \qquad [3]$$
$$INN^{*} = X_2\beta_2 + e_2 \qquad [4]$$

This model is identified and it can be consistently and efficiently estimated by full information maximum likelihood (*FIML*) estimation treated as a bivariate probit model, ignoring the simultaneity (Greene, 2003). The estimated equations are:

$$FATT = \alpha_1 INN + X_1\Pi_1 + u_1 \qquad [3a]$$
$$INN = X_2\Pi_2 + u_2 \qquad [4a]$$

The estimation of a recursive multivariate probit model requires some consideration for the identification of the model parameters. Maddala (cf. 1983, p. 123) proposes that at least one of the reduced-form exogenous variables is not included in the structural equations as explanatory variables. Wilde (2000) states that Maddala concentrates on the special case of constant only exogenous regressors and that the argumentation is valid only for this case. Consequently, the parameters of the model are identified if there exists at least one varying exogenous regressor. According to Wilde, there is sufficient variation in the data to identify the parameters even in this simple case. In our model, we follow the Maddala approach and impose exclusion restrictions. All exclusion were decided by first including the variables in both equations and omitting then form the equation(s) in which they were insignificant. We decide to include the legal form of the firm and the professional training variables in our estimated probability of innovation, but we exclude these variables from our estimated probability of increased sales. These two exclusions

can also be justified theoretically because the legal form and the training activities can influence the increasing sales indirectly through the innovation process.

The explanatory variables that we use in our empirical model can be divided into three groups:

1) Firm-specific characteristics:

- Legal form;
- Economic sector;
- Total number of employees;
- Founder of the firm;
- Age of the firms (i.e., the number of years since the firm's inception);
- Firms' output (i.e., intermediate products, final products or both);
- Firms' market (i.e., local markets, non-local markets, or both[21]);
- Training courses during the last three years.

2) Entrepreneur-specific characteristics:

- Highest educational level of the owner/entrepreneur[22];
- Owner's age (average age if more than one owner/entrepreneur exists);
- Owner's previous occupation[23];
- Years of experience as an entrepreneur (the sum of experience's if more than one owner/entrepreneur exists).

3) Network characteristics:

- Degree of Workers' participation in a firm's decisions ;
- Educational levels of the workers;
- Affiliation with a consortium or other corporate link;
- Sense of belonging to the local community;
- Importance of the firm's relationships with other firms in the area;
- Affiliation with a district area[24].

[21] The local markets in our study are the province of Salerno, the Campania region and the South of Italy.
[22] If there is more than one entrepreneur, then we consider the highest level of education among the entrepreneurs.
[23] If we have more than one entrepreneur/partner we consider the prevalently activity among them. If there isn't a prevalentely activitves we consider the previous activities of the first partner.
[24] This Industrial District (ID) includes 15 municipalities from Salerno's province: Angri; Baronissi; Bracigliano; Castel san giorgio; Mercato San Severino; Nocera Inferiore; Nocera Superiore; Pagani;

We decide to impute the missing values of the following fundamental variables: the year of the firm's inception, the founder of the firm, the degree to which the employees participate in the firm's decision-making process and the employees' educational levels. The variables used for the imputation are the firm's legal form, the firm's economic sector and whether the firm has produced at least one innovation.

We use the Imputation by Chained Equations (ICE) approach, which is based on each variable's conditional density given the presence of other variables. We included the variables to be imputed and those to be used only for the purpose of imputing other variables (Royston, 2009; Royston, Carlin and White, 2009).

5. The results

By examining table 7 and table 8, we determine the probability that a firm will innovate and the probability of increased sales. We consider three models:

- First, we estimate the simple univariate probit model, without control for the correlation or simultaneity;
- Second, we estimated the reduced form equations with the bivariate probit model
- Third, we estimate the recursive simultaneous equation model with a recursive bivariate probit model[25].

To check the robustessnes of the results, in the second specification we try to excludes some variables that can be correlated with the entrepreneur's education level as: owner's previous occupation, years of experience as an entrepreneur and economic sector of the firm.

Roccapiemonte; San Marzano sul Sarno; San Valentino Torio; Sant'Egidio del Monte Albino; Sarno; Scafati; Tramonti.. The ID specialises in tomatoes production of other canned foods.

[25] In the recursive bivariate probit model, the computation of marginal effects is complicated by the fact that the explanatory variables appearing in the equation for the endogenous dummy have an indirect effect (through the endogenous dummy) on the outcome of the primary interest as well as a direct effect if they also appear in the first equation. The marginal effects in these paper are building following the formula in Greene, 1998 modified in Baslevent and El-hamidi (2009). We highlight that the formulation of marginal effect could be applied to binary explanatory variables especially if one is interested in decomposing the total effect into its direct and indirect components. However a more accurate definition for total marginal effect of binary could be applied and it's an impact difference effect of the binary variable (1/0) on the joint probability . We report the marginal effect that can be considered the derivative of the joint probability respect to the an explanatory variables. The effect of introduce an innovation can be evaluated by the difference between the conditional probabilities of increased sales when innovation is introduced or not (Kassouf and Hoffmann, 2005).

With regard the estimates of ρ, its values is positive (+ 0.21) in the reduced – form model (II) and negative in the structural model (III) (-0.64) (table 7 and 8) and it is significant then the null hypothesis that $\rho=0$ is rejected. We are reassured that our recursive model provides more reliable than a single equation model. The negative ρ estimate, which may at first seem counter-intuitive given that the coefficient on innovation is positive, is in fact of the expected sign. It implies that once "innovativeness" is controlled for in Equation 1 (*FATT)* unobserved characteristics that make a firm more likely to increasing sales, also make them less likely or "necessary" to introduce innovation. We think that the best model is the recursive bivariate model, the third model, but there aren't great differences among them.

With regard to the estimates of the probability of innovation (table 7) the variables that are statistically significant for all of the specifications are the following: the economic sector, where the wood and metal products industries have lower probabilities of producing innovations (-23 percentage points) while increase by 24 percentage points for the manufacturers operating in the paper, printing and publishing industries in comparison with the manufacturers of machinery, equipment and other products.

Because printers and lithographers have to constantly adapt to new technologies aimed at improving the quality of their products (e.g., multimedia printing), the paper, printing and manufacturing companies are highly innovative. As predicted by the traditional models, the probability of innovation increases as the size of the firms increase. This result is confirmed by the sign and the significance of the coefficient of the number of employees who have less than secondary school.

Nevertheless, the significance of this result is lower when we control for the correlation between innovation and increased firms' sales (bivariate probit models). In other words, the increased sales is positively linked to the number of workers who did not graduate from secondary this result is caused by a strong positive relation between the increased sales and the dimensions of the firms. The workers' low educational levels served as a proxy for the dimensions of the firms.

Furthermore, our hypothesis on the positive link between firm *knowledge*, which was measured by the educational level, experience and network, and firm innovation is confirmed because the probability of innovation increases if the firm is led by an entrepreneur with a high education level (+26.1), if the firm invests in professional

training (+18.4), if the previous occupation was entrepreneur (+15.6) and if the firm's workers participate in the firm's decision-making process to a high degree (+20.4). The networks external to the firm are irrelevant to the firm's probability of innovation.

Table 7 around here

With respect to the results of the probability of increased sales (Table 8) first of all the variable innovation is positive and significant.

Following we discuss the net effects, unless particular results let us to describe the two effects separately . We found that the paper, publishing and printing industries suffered a crisis from 1995-1998. Additionally, firms led by older owners/entrepreneurs did well, but only if the owners/entrepreneurs were less than 40 years old. With regards the firms that sell abroad, we can see the two effects (direct and indirect) go in same direction (positive).

The probability of increased sales is higher if the entrepreneur was self-employed before starting the firm (+ 29.5 percent point – net/total effect). Instead, the firms' performance levels decrease as the number of the workers with only professional qualifications increases (-0,037) .

With respect to our theoretical hypothesis, the results are particularly interesting. According to the data, an entrepreneur with only a secondary education exhibited the strongest performances. In general, entrepreneurs with lower educational levels were more likely to experience increased sales than entrepreneurs who graduated from a tertiary school. To control the robustness of the results, we exclude variables that can explain these results. For example, we control for the sectoral classification, the entrepreneurs' previous occupations and the number of years spent working as an entrepreneur. The results are the same. Thus, we are not able to explain why less educated entrepreneurs exhibit superior market sales.

If we look at the direct and indirect effect, we can see that the two effect have quite often opposite sign. For instance, with regard to the entrepreneur's educational level the direct effect is positive, while the indirect effect is negative, and we can argue that the entrepreneur with lower educational levels, have higher performance but lower likelihood of innovate. In each case the direct effect dominates, and so the net effect turn be negative.

We also calculated the value predicted by the three different levels of educations. We held the following covariates constant: sole proprietorship; paper, printing and publishing sectors; selling the final product; selling to local markets; lack of professional training; the high participation rates of employees in the firm's decisions; the entrepreneur's previous activities in entrepreneurship; lack of affiliation with a consortium; and lack of connections to the local area and other firms. The continuous variables are equal to the corresponding means. Additionally, we repeat this calculation with all of the variables at the mean. Finally, we repeat this calculation for the two last models (bivariate probit and recursive bivariate probit) and we let vary the innovation and set it equal to 1, then to 0 and then to estimated mean. As can be seen in table 9, the higher the educational level of the entrepreneur is, the higher the probability that the firm will innovate. In particular, this probability conditioned to the increased sales is 96.9% if the owner/entrepreneur graduated from a tertiary school, 90% if the owner/entrepreneur only graduated from a secondary school, and 87.6% if the owner/entrepreneur did not graduate from secondary school.

Our results also show that entrepreneurs with tertiary levels of education have lower estimated probabilities of increased sales (6.8% if they innovate and 2.4% if they don't). compared to an entrepreneurs with lower educational levels.

With respect to the table 10A, we can se that the results are very different, the conditional probability of increased sales is lower if we consider to have/ extract potentially innovative firms and higher if we extract potentially not innovative firms (this results depend from the negative sign of ρ). Look at the conditional mean, should seem that innovate decreased the probability of increased sales. This is not true, this results say only that the firms more likely to innovate are those which have structurally less likely to increase sales. The firms which lose less (6.3% and 32.5%) are those where the entrepreneur has a university degree, and are the firms which have more need to innovate for increasing their revenue and catching up the other firms. The economic reason of this result is not explained by our data but it depends by an unobservable variable describing any characteristic of entrepreneur as quality of education or other professional experiences or some variables pertinent to the market where the firms is involved.

Finally, if all of the firms sign an agreement to not innovate, then the differences among them will decrease. This finding shows that innovation makes firms more competitive and

increases the differences among the firms. However, because the probability of increased sales declines for all of the firms, this result is not efficient for the system as a whole. Without this agreement, firms should innovate to maximise their competitiveness.

In any case the probability of increased sales is lower if the firms is effectively innovative. For instance with regard less educated entrepreneur the P(*FATT=1|INN=1)* is 16% if all firms innovate, 1,1% if they don't innovate. Then the impact of the innovation process on the increase in firm sales is positive and equal to 15 percentage point (the marginal effect for the variable "innovation") for entrepreneur with less than secondary school, 16.1 for secondary school and 6 percentage point for entrepreneur with university degree.

Besides, look at the table 10B where we highlight also the joint probability of increased sales estimated at the average of the probability of innovation. Entrepreneur with the tertiary school manage to recover positions compared with less educated entrepreneur (the difference is only 3 percentage point to less than secondary and 6 percentage point to the entrepreneur with secondary school. These last have the best position in terms of increased revenue. The probability of increased sales is more than 8% (joint probability) and 10% the conditional probability when the firms are innovative (9% and 39% if they are not innovative).

6. Conclusions

In this paper, we analysed the causes and the effects of innovation on a territory characterised by the presence of small- and medium-sized firms. As we noted previously, these types of firms are limited in their pursuit of innovation. We accepted a broader definition of innovation as a "*new or significantly improved production methods, including methods of product delivery*" (OECD 1997 p.49) or "something new or an improvement that applies to a firm". and define innovation as "new ideas that are introduced in the firm in many ways and that allow the firm to get an advantage" (Adams et al. 2006, p. 22). Then innovation is defined a level of firms.

Besides, we can define the word "innovation" not only by its semantics (i.e., innovation represents something new to a firm) but also by its effects on a firm as a whole. That is, innovation also generates an advantage for the firm. According to our approach, innovation consists of new ideas that create an advantage for the firm. Then cause and effect of innovation cannot be separated and for these reason we applied two different bivariate models.

With regards the cause of innovation we believes that innovation depends on *firm's ability to assimilate and exploit existing information*" and on "*the firms' ability to identify, assimilate and exploit knowledge from the environment* . The first source of knowledge is the R&D. However, for small- and medium-sized firms that do not have institutional R&D functions or activities, this channel of knowledge is unavailable. For us the main sources of knowledge in SMEs are human capital and networks. In fact, human capital and networks are practically the only sources of knowledge for SMEs. When we refer to human capital, we consider the entrepreneur's and the employees' educational levels and previous experiences. Furthermore, if the firm's stock of knowledge is contingent on the availability of information, this information depends on the relationships and the networks that the firm, whether big or small, has established both within the firm and external to the firm. These types of networks generally produce positive externalities à la Marshall. The networks utilised by small- and medium-sized firms have different origins and can relate to the firms' participation in consortiums and the firms' relationships with various actors,

such as suppliers, buyers, and customers. In the case of small- or medium-sized firms, the network is mainly informal and involves the firm's links to the surrounding environment. Summarizing the results we found that

- Human capital play a positive role in innovation in SMEs but a negative effect for the probability of increased sales.
- Dimension of the firm, training, worker participation at the decision of the firm play a positive role on the probability of innovation but are no significant for the probability of increased sales;
- Sells in non local market beyond the South, experiences as self employment and an higher age of the owner leads to rise the probability to increased sales
- Firms more innovative are those which have structurally less likely to increase sales. The firms which lose less in conditional probability to increased sales when the firms innovate or not, are those where the entrepreneur has a university degree
- Firms with higher educated owner are the firms which have more need to innovate for increasing their revenue and to catching up the other firms.
- Firms with owner with secondary school have the best perfomance.
- The economic reason of these results remain also if we control for all the available variables then they are not explained by our data and they depend by an unobservable variable describing some characteristics of entrepreneur as quality of education or other professional experiences or some variables pertinent to the market where the firms is involved.

If we would try to find a suggestion we could say that in a province in the South of Italy extending the sales market beyond South and professional experiences are important to increase sales **.**

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Figure 1 – A model of the innovative capability of the firms

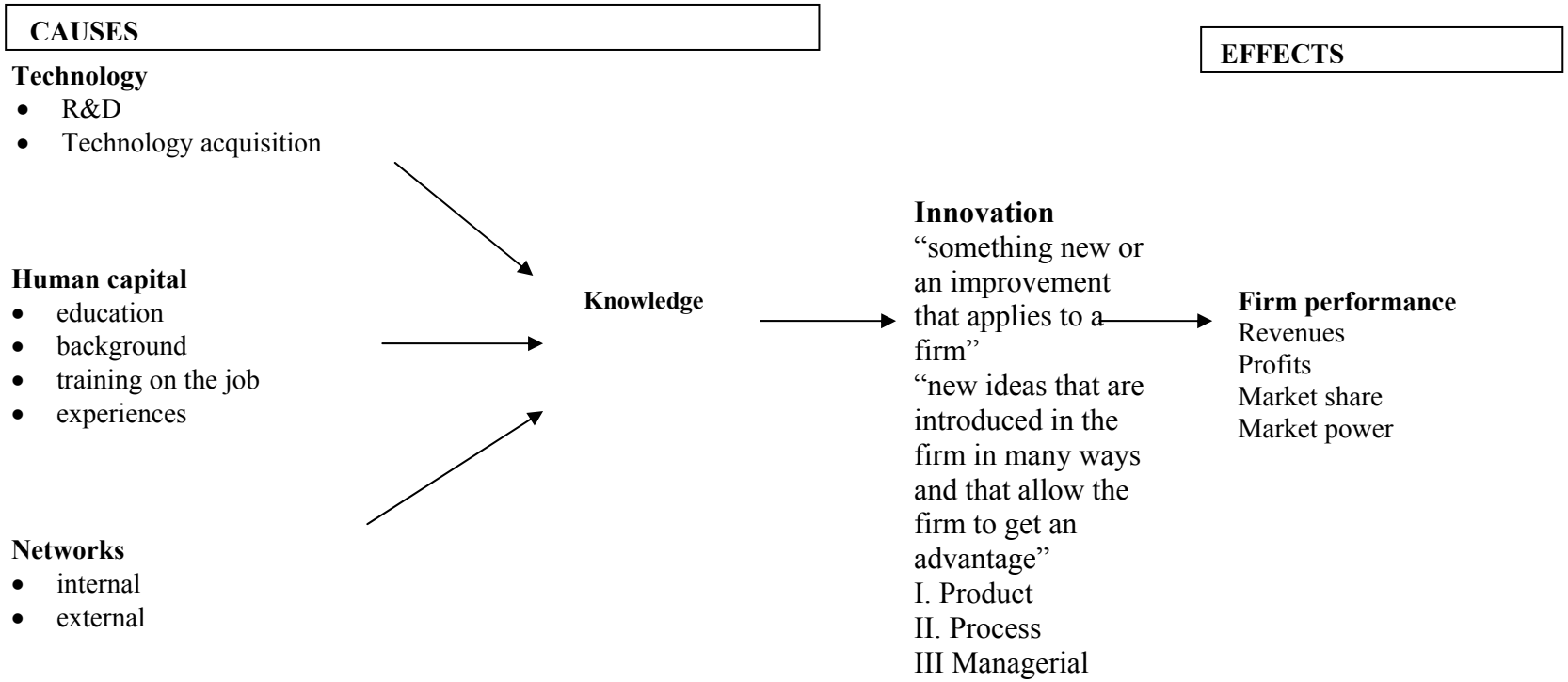

Table 1 Innovation Frequencies

Innovation	N. 415
	%
No	57.24.
Yes	42.76
Total	100.00

Source: Own elaborations with OPIS data

Table 2 Type of innovation

Type of Innovation	N. 177
	%
Product Innovation	49.05
Process Innovation	61.88
Managerial Innovation	15.78

Source: Own elaborations with OPIS data

Table 3 Relative frequencies of increased sales while introducing or not innovation process according to the OPIS database, in the Salerno Province

Innovation	Increased sales		Total		
	Yes	No		Conditional probability	
Yes	85	111	196		
	20.5%	26.7%	47.2%	43.4%	(FATT=1|INN=1)
No	59	160	219		
	14.2%	38.6%	52.8%	26.9%	(FATT=1|INN=0)
Total	144	271	415		
	34.7%	65.3%	100.0%		
Conditional probability	59.0%	41.0%			
	(INN=1|FATT=1)	(INN=1|FATT=0)			

Source: Own elaborations with OPIS data

Table 4 Descriptive statistics

	Mean	Mean	Mean
Dependent Variables	**Entire sample (N. 415)**	**Innovative firms (N. 196)**	**Firms with increased sales (n. 144)**
Innovation (Yes 1/0)	42.75%	100.00%	55.46%
N. innovation	0.701	1.64	0.95
Market Performance (increased sales) (Yes 1/0)	32.80%	42.54%	100.00%
Characteristics of the firms			
Legal Form			
Sole proprietorship (Yes 1/0)	50.3%	30.35%	40.27%
Private company (Yes 1/0) $	49.7%	69.65%	
Pavitt Sector			
Science-based sectors/firms (Yes 1/0)	6.4%	6.4%	3.26%
Scale- intensive sectors/firms (Yes 1/0)	22.1%	26.8%	21.79%
Specialized equipment sectors/firms (Yes 1/0)	11.5%	12.8%	16.07%
Supplier-dominated sectors/firms (Yes 1/0) $	60.1%	54.0%	%
Economic sector			
Food, drink and tobacco industries (Yes 1/0)	22.0%	26.4%	22.57%
Textiles and leather industries (Yes 1/0)	12.6%	9.6%	9.70%
Wood and metal products industries (Yes 1/0)	24.2%	12.3%	21.9%
Manufacturers of paper pulp, paper, cardboard and paper products; printing and publishing industries (Yes 1/0)	5.4%	8.7%	5.08%
Manufacturers of chemical products and synthetic and artificial fibres and rubber (Yes 1/0)	3.1%	4.9%	2.97%
Manufacturers of products based on non-metallic minerals (Yes 1/0)	7.9%	10.0%	9.41%
Manufacturers of machinery, equipment and other products (Yes 1/0)$	24.8%	28.1%	28.37%
Dimension of the firm			
Total number of employees	9.54	16.45	14.8
Founder of the firm			
Actual owner (Yes 1/0)	70.1%	66.5%	74.45%
Previous generation (Yes 1/0)	24.0%	24.9%	20.46%
Other (Yes 1/0)$	5.9%	8.6%	5.09%
Age of the firm			
Number of years	20.70	22.08	21.9
Type of products			
Intermediate commodities (Yes 1/0)	10.6%	12.0%	9.39%
Final products (Yes 1/0)	77.7%	71.9%	71.50%
Intermediate and final products (Yes 1/0)$	11.7%	16.1%	19.11%
$ Excluded variables			

(continues)

Table 4 Descriptive statistics (continued)

	Mean	Mean	Mean
Dependent Variables	**Entire sample (N. 415)**	**Innovative firms (N. 196)**	**Firms with increased sales (n. 144**
The firms also or only sell in non-local markets (Yes 1/0)	33.7%	46.2%	47.28%
Training during the last three years (Yes 1/0)	31.3%	45.3%	
Employee participation levels			
None (Yes 1/0)$	30.4%	11.5%	22.13%
High (Yes 1/0)	13.1%	19.6%	17.07%
Medium (Yes 1/0)	28.2%	34.7%	34.05%
Low (Yes 1/0)$	8.2%	10.9%	8.82%
Characteristics of the entrepreneur			
Education			
Less than secondary school (Yes 1/0)	42.9%	26.1%	33.38%
Secondary school (Yes 1/0)	43.2%	50.6%	55.89%
Tertiary school or university (Yes 1/0)$	13.9%	23.3%	10.73%
Age	43.12	42.48	41.50
Previous occupation			
Employees (Yes 1/0)	40.2%	32.7%	42.67%
Student or unemployed (Yes 1/0)$	25.8%	24.5%	25.6%
Self-employed (Yes 1/0)	5.0%	4.2%	8.0%
Entrepreneur (Yes 1/0)	27.9%	35.9%	21.5%
Other or housewife (Yes 1/0)$	1.1%	2.6%	%
Years of experience as an entrepreneur (total)	23.69	28.07	24.7
Number of employees by education level			
Less than secondary school	7.07	10.38	10.55
Secondary school	3.85	6.47	5.16
Professional school (three years)	0.46	0.52	0.26
Tertiary school or university	0.60	0.97	0.73
Network			
Consortium (Yes 1/0)	7.4%	12.1%	10.18%
Partnership (Yes 1/0)	4.3%	7.8%	4.9%
Link with the territory (Yes 1/0)	82.0%	78.0%	81.7%
Importance of link to other firms (Yes 1/0)	16.0%	22.2%	17.01%
Affiliation with a district (Yes 1/0)	29.3%	33.0%	35.62%
$ Excluded variables			

Source: Own elaborations with OPIS data

Table 5A Percentage of innovative firms by relevant characteristics

Legal Form	**%**
Sole proprietorship (Yes 1/0)	**29.41%**
Company (Yes 1/0) $	**64.18%**
Pavitt Sector	
Science-based sectors/firms (Yes 1/0)	**47.42%**
Scale- intensive sectors/firms (Yes 1/0)	**56.30%**
Specialized equipment sectors/firms (Yes 1/0)	**52.42%**
Supplier-dominated sectors/firms (Yes 1/0) $	**42.78%**
Consortium	
Yes	**73,56%**
No	**45.00%**
Education	
Less than secondary school (Yes 1/0)	**29.64%**
Secondary school (Yes 1/0)	**57.78%**
Tertiary school or university (Yes 1/0)$	**75.24%**

Table 5B Percentage of firms with increased sales by relevant characteristics

Legal Form	**%**
Sole proprietorship (Yes 1/0)	**27.88%**
Company (Yes 1/0) $	**41.55%**
Pavitt Sector	
Science-based sectors/firms (Yes 1/0)	**18.52%**
Scale- intensive sectors/firms (Yes 1/0)	**34.07%**
Specialized equipment sectors/firms (Yes 1/0)	**47.92%**
Supplier-dominated sectors/firms (Yes 1/0) $	**34.14%**
Consortium	
Yes	**33.59%**
No	**48.39%**
Education	
Less than secondary school (Yes 1/0)	**27.12%**
Secondary school (Yes 1/0)	**44.44%**
Tertiary school or university (Yes 1/0)$	**26.32%**
Also or only sells in non-local markets	
No	**27.47%**
Yes	**48.23%**
Producer of intermediate commodities and final products	
No	**40.00%**
Yes	**56.00%**

Source: Own elaborations with OPIS data

Table 6 Number of innovations (mean) by relevant characteristics

Legal Form	**Mean**
Sole proprietorship (Yes 1/0)	1.409
Company (Yes 1/0) $	1.734
Pavitt Sector	
Science-based sectors/firms (Yes 1/0)	2.360
Scale- intensive sectors/firms (Yes 1/0)	1.662
Specialized equipment sectors/firms (Yes 1/0)	1.483
Supplier-dominated sectors/firms (Yes 1/0) $	0.572
Consortium	
Yes	1.604
No	1.861
Education	
Less than secondary school (Yes 1/0)	1.364
Secondary school (Yes 1/0)	1.728
Tertiary school or university (Yes 1/0)$	1.738

Source: Own elaborations with OPIS data

Table 7 Estimated probabilities of innovation

	Univariate probit				Recursive bivariate probit - Marginal probability				Bivariate probit - conditional probability (I specification)				Bivariate probit conditional probability (II specification)			
Dependent variable: Innovation (1/0)	Marginal effect	Robust Standard Error	z		Marginal effect	Robust Standard Error	z		Marginal effect	Robust Standard Error	z		Marginal effect	Robust Standard Error	z	
Legal form: sole proprietorship (1/0)	-0.109	0.083	-1.30		-0.122	0.076	-1.600		-0.165	0.076	-2.19	**	-0.103	0.086	-1.20	
Food, drink and tobacco industries (1/0)	-0.030	0.101	-0.29		-0.032	0.099	-0.330						-0.010	0.106	-0.10	
Textiles and leather industries (1/0)	-0.145	0.090	-1.51		-0.140	0.087	-1.600	*					-0.134	0.102	-1.31	
Wood and metal products industries (1/0)	-0.225	0.091	-2.25	**	-0.231	0.089	-2.590	**					-0.225	0.102	-2.20	**
Manufacturers of paper pulp, paper, cardboard and paper products; printing and publishing industries (1/0)	0.219	0.113	1.88	*	0.196	0.111	1.770	*					0.245	0.101	2.43	**
Manufacturers of chemical products and synthetic and artificial fibres and rubber (1/0)	0.037	0.134	0.27		0.035	0.129	0.270						0.063	0.139	0.46	
Manufacturers of products based on non-metallic minerals (1/0)	0.026	0.115	0.23		0.021	0.119	0.170						0.040	0.120	0.33	
Founder of the firm: actual owner (1/0)	-0.100	0.142	-0.71		-0.091	0.140	-0.650		-0.119	0.141	-0.85		-0.129	0.152	-0.85	
Founder of the firm: previous generation (1/0)	-0.035	0.140	-0.25		-0.027	0.140	-0.200		-0.087	0.143	-0.61		-0.045	0.151	-0.30	
Age of the firm	-0.004	0.005	-0.79		-0.003	0.005	-0.750		-0.002	0.004	-0.54		-0.004	0.005	-0.86	
Squared age of the firm	0.000	0.000	0.43		0.000	0.000	0.450		0.000	0.000	0.26		0.000	0.000	0.30	
Producer of intermediate commodities (Yes 1/0)	-0.053	0.119	-0.44		-0.063	0.115	-0.550		-0.009	0.123	-0.08		-0.017	0.127	-0.13	
Producer of final products (Yes 1/0)	-0.018	0.093	-0.19		-0.044	0.096	-0.460		-0.015	0.094	-0.16		0.015	0.098	0.15	
Also or only sells in non-local markets (1/0)	0.076	0.070	1.08		0.077	0.068	1.130		0.074	0.069	1.08		0.050	0.072	0.70	
Participation of workers: high (1/0)	0.228	0.110	2.02	**	0.204	0.113	1.800	*	0.244	0.093	2.64	***	0.219	0.101	2.16	**
Participation of workers: medium (Yes 1/0)	0.090	0.086	1.05		0.067	0.087	0.770		0.068	0.084	0.81		0.091	0.087	1.04	
Participation of workers: low (1/0)	0.133	0.124	1.07		0.100	0.120	0.830		0.095	0.116	0.82		0.158	0.118	1.34	

legend: * p<.1; ** p<.05; *** p<.01

(continues)

Table 7 Estimated probabilities of innovation (continued)

	Univariate probit				Recursive bivariate probit - Marginal probability				Bivariate probit - conditional probability (I specification)				Bivariate probit - conditional probability (II specification)			
Dependent variable: Innovation (1/0)	**Marginal effect**	**Robust Standard Error**	**z**		**Marginal effect**	**Robust Standard Error**	**z**		**Marginal effect**	**Robust Standard Error**	**z**		**Marginal effect**	**Robust Standard Error**	**z**	
Training during the last three years (Yes 1/0)	0.168	0.071	2.35	**	0.184	0.063	2.91	***	0.135	0.071	1.89	*	0.151	0.073	2.09	**
Owner's education: less than secondary school (Yes 1/0)	-0.262	0.102	-2.44	**	-0.261	0.102	-2.55	***	-0.278	0.104	-2.68	***	-0.302	0.107	-2.82	***
Owner's education: secondary school (Yes 1/0)	-0.189	0.090	-2.04	**	-0.168	0.092	-1.83	*	-0.196	0.093	-2.11	**	-0.236	0.092	-2.56	**
Age	0.003	0.008	0.31		0.002	0.009	0.20		-0.002	0.009	-0.28		0.001	0.009	0.07	
Squared Age	0.000	0.000	-0.40		0.000	0.000	-0.19		0.000	0.000	0.33		0.000	0.000	-0.09	
Previous occupation of the entrepreneur: Employee (Yes 1/0)	0.077	0.081	0.95		0.069	0.077	0.89						0.061	0.082	0.74	
Self-employed (Yes 1/0)	-0.047	0.135	-0.34		-0.046	0.141	-0.33						-0.092	0.144	-0.64	
Entrepreneur (Yes 1/0)	0.164	0.089	1.85	*	0.156	0.089	1.75	*					0.175	0.086	2.04	**
Years of experience as an entrepreneur (total)	0.003	0.002	1.47		0.003	0.002	1.29						0.003	0.002	1.51	
Number of employees who did not graduate from secondary school	0.006	0.003	1.98	**	0.005	0.003	2.00	**	0.004	0.003	1.52		0.005	0.003	1.63	
Number of employees who graduated from secondary school	0.003	0.004	0.68		0.001	0.004	0.28		0.004	0.004	0.96		0.003	0.005	0.76	
Number of employees with professional qualifications (less than three years)	-0.018	0.012	-1.54		-0.018	0.011	-1.59		-0.021	0.012	-1.70	*	-0.013	0.013	-1.01	
Number of employees with tertiary education	-0.003	0.008	-0.41		-0.001	0.007	-0.17		0.002	0.007	0.34		-0.006	0.008	-0.68	
Consortium (Yes 1/0)	0.051	0.126	0.41		0.043	0.124	0.35		0.104	0.120	0.86		0.036	0.132	0.27	
Partnership (Yes 1/0)	0.141	0.155	0.91		0.135	0.147	0.91		0.096	0.156	0.62		0.150	0.145	1.03	
Link with the territory (Yes 1/0)	-0.055	0.078	-0.70		-0.051	0.079	-0.64		-0.081	0.080	-1.01		-0.070	0.081	-0.87	
Importance of link to other firms (Yes 1/0)	0.091	0.092	1.00		0.088	0.089	0.99		0.112	0.089	1.26		0.095	0.092	1.03	
Affiliated with a district (1/0)	0.064	0.077	0.84		0.075	0.076	0.99		0.022	0.073	0.30		0.049	0.077	0.63	
Nobs	415				415				415				415			
Wald chi	110.0				294.09				158.09				203.68			
Pseudo R2	0.2441															
Rho£					-0.635	Chi2(1)= 3.321	P>chi 2=0.0 68	*	0.154	2.120	0.15		0.213	4.041	0.044	**

LL					-8582.36								-8601.38			

legend: * p<.1; ** p<.05; *** p<.01 ⁄for rho we present the chi2 test

Source: Own elaborations with OPIS data

Table 8 Estimated probabilities of increased sales

	Univariate probit				Recursive bivariate probit				Bivariate probit - conditional probability (I specification)				Bivariate probit - conditional probability (II specification)			
Dependent variable: Increased sales (1/0)	Marginal effect	Robust Standard Error	z		Direct effect	Indirect effect	Total effect	Sig	Marginal effect	Robust Standard Error	z		Marginal effect	Robust Standard Error	z	
Legal form: sole proprietorship (1/0)	-					-0.066	-0.066									
Innovation (1/0)					0.537		0.537	***								
Food, drink and tobacco industries (1/0)	-0.106	0.078	-1.29		-0.094	-0.017	-0.111						-0.112	0.088	-1.27	
Textiles and leather industries (1/0)	-0.133	0.073	-1.65	*	-0.071	-0.079	-0.150						-0.131	0.086	-1.52	
Wood and metal products industries (1/0)	-0.093	0.087	-1.02		-0.003	-0.132	-0.135						-0.068	0.101	-0.67	
Manufacturer of paper pulp, paper, cardboard and paper products; printing and publishing industries (1/0)	-0.142	0.075	-1.65	*	-0.259*	0.104	-0.155	**					-0.182	0.086	-2.11	*
Manufacturer of chemical products and synthetic and artificial fibres and rubber (1/0)	-0.138	0.089	-1.33		-0.167	0.019	-0.148						-0.160	0.106	-1.50	
Manufacturer of products based on non-metallic minerals (1/0)	-0.076	0.088	-0.82		-0.093	0.011	-0.082						-0.085	0.102	-0.84	
Founder of the firm: actual owner (1/0)	0.098	0.114	0.83		0.164	-0.049	0.115		0.144	0.127	1.13		0.132	0.134	0.98	
Founder of the firm: previous generation (1/0)	0.015	0.133	0.11		0.046	-0.015	0.031		-0.001	0.143	-0.01		0.031	0.151	0.21	
Age of the firm	0.000	0.004	0.09		0.002	-0.002	0.000		0.001	0.004	0.17		0.001	0.005	0.13	
Squared age of the firm	0.000	0.000	0.83		0.00002	0.0000	0.000		0.000	0.000	0.74		0.000	0.000	0.79	
Producer of intermediate commodities (Yes 1/0)	-0.151	0.084	-1.55		-0.161	-0.035	-0.196		-0.161	0.096	-1.68	*	-0.172	0.098	-1.75	*
Producer of final products (Yes 1/0)	-0.155	0.085	-1.87	*	-0.141	-0.024	-0.165		-0.119	0.092	-1.30		-0.165	0.091	-1.81	*
Also or only sells in non-local markets (Yes 1/0)	0.173	0.065	2.72	***	0.126	0.041	0.167	*	0.157	0.067	2.34	**	0.176	0.067	2.62	***
Participation of workers: high (Yes 1/0)	0.067	0.092	0.75		-0.031	0.108	0.077		0.090	0.099	0.91		0.042	0.097	0.43	
Participation of workers: medium (Yes 1/0)	0.037	0.071	0.52		-0.002	0.036	0.034		0.056	0.078	0.72		0.029	0.078	0.38	
Participation of workers: low (1/0)	-0.067	0.087	-0.74		-0.137	0.053	-0.084		-0.065	0.0943	-0.69		-0.093	0.097	-0.96	

legend: * p<.1; ** p<.05; *** p<.01 (continue)

Table 8 Estimated probabilities of increased sales (continued)

	Simple probit				Recursive bivariate probit				Bivariate probit - conditional probability (I specification)				Bivariate probit - conditional probability (II specification)			
Dependent variable: Increasing sales (1/0)	**Marginal effect**	**Robust Standard Error**	**z**		**Direct effect**	**Indirect effect**	**Total effect**	Sig	**Marginal effect**	**Robust Standard Error**	**z**		**Marginal effect**	**Robust Standard Error**	**z**	
Training during the last three years (Yes 1/0)	0.097	0.067	1.47			0.098	0.098		0.085	0.072	1.19		0.079	0.072	1.09	
Owner's education: less than secondary school (Yes 1/0)	0.143	0.104	1.38		0.282	-0.144	0.138	***	0.163	0.109	1.49		0.192	0.111	1.73	*
Owner's education: secondary school (Yes 1/0)	0.186	0.094	1.98	**	0.272	-0.092	0.180	***	0.201	0.099	2.02	**	0.229	0.101	2.27	**
Age	0.015	0.007	2.13	**	0.015	0.0009	0.016	*	0.018	0.008	2.46	**	0.016	0.008	1.99	**
Squared Age	-0.000	0.000	-2.52	**	-0.0002	-0.00001	0.000	**	-0.000	0.000	-2.79	***	-0.000	0.000	-2.38	**
Previous occupation of the entrepreneur: Employees (Yes 1/0)	0.117	0.074	1.60		0.093	0.037	0.130						0.115	0.079	1.46	
Self-employed (Yes 1/0)	0.303	0.138	2.19	**	0.320	-0.025	0.295	**					0.314	0.135	2.32	*
Entrepreneur (Yes 1/0)	-0.031	0.077	-0.39		-0.086	0.083	-0.003						-0.059	0.082	-0.73	
Years of experience as an entrepreneur (total)	0.001	0.002	0.63		-0.0008	0.002	0.001						0.001	0.002	0.37	
Number of employees who did not graduate from secondary school	0.005	0.002	2.05	**	0.003	0.003	0.006		0.004	0.003	1.66	*	0.005	0.003	1.70	*
Number of employees who graduated from secondary school	0.001	0.003	0.38		0.002	0.001	0.003		0.001	0.003	0.21		0.001	0.003	0.25	
Number of employees with professional qualifications (less than three years)	-0.032	0.010	-3.22	***	-0.027	-0.010	-0.037	***	-0.031	0.011	-2.86	***	-0.033	0.011	-2.91	***
Number of employees with tertiary education	0.007	0.007	0.99		0.009	-0.006	0.003		0.004	0.007	0.59		0.008	0.007	1.11	
Consortium (Yes 1/0)	0.099	0.103	1.00		0.067	0.023	0.090		0.085	0.111	0.77		0.104	0.110	0.94	
Partnership (Yes 1/0)	-0.045	0.119	-0.36		-0.093	0.011	-0.082		-0.059	0.126	-0.47		-0.062	0.131	-0.48	
Link with the territory (Yes 1/0)	0.067	0.068	0.95		0.087	-0.027	0.060		0.080	0.076	1.06		0.080	0.077	1.04	
Importance of link to other firms (Yes 1/0)	-0.007	0.082	-0.09		-0.049	0.047	-0.002		-0.014	0.087	-0.16		-0.016	0.090	-0.18	
Affiliation with a district (1/0)	0.071	0.069	1.05		0.049	0.040	0.089		0.049	0.0692	0.71		0.069	0.074	0.94	
Nobs	415				415				415				415			
Wald chi	70.08				294.09				158.09				203.68			
Pseudo R2	0.1517															
Rho£					-0.635	Chi2(1)=3.321	>chi2=0.68	*	0.154	2.120	0.15		0.213	4.041	0.044	**
LL					-8582.36								-8601.38			

legend: * p<.1; ** p<.05; *** p<.01; £for rho we present the chi2 test

Source: Own elaborations with OPIS data

Table 9 Probability (in%) of increase in firm's sales while introducing or not an innovation, in the estimated bivariate probit model.

Bivariate probit&
Less than secondary education

	Increase in Sales		Total		
Innovation	Yes	No			
Yes	10.6	65.4	76	**13.9**	Conditional Prob FATT=1|INN=1
No	1.5	22.4	23.9	**6.3**	Conditional Prob FATT=1|INN=0
Total	12.1	87.8	100	-	
Conditional Prob. Inn=1	**87.6**	**74.5**			

Secondary education

	Increase in Sales		Total		Conditional Prob. Fatt=1
Innovation	Yes	No			
Yes	13.2	68.1	81.3	**16.2**	Conditional Prob FATT=1|INN=1
No	1.4	17.3	18.7	**7.5**	Conditional Prob FATT=1|INN=0
Total	14.6	85.4	100	-	
Conditional Prob. Inn=1	**90.4**	**79.7**			

Tertiary education

	Increase in Sales		Total		Conditional Prob. Fatt=1
Innovation	Yes	No			
Yes	6.2	85.4	91.6	**6.8**	Conditional Prob FATT=1|INN=1
No	0.2	8.1	8.3	**2.4**	Conditional Prob FATT=1|INN=0
Total	6.4	93.5	100	-	
Conditional Prob. Inn=1	**96.9**	**91.3**			

Total

	Increase in Sales		Total		Conditional Prob. Fatt=1
Innovation	Yes	No			
Yes	11	68.9	79.9	**13.8**	Conditional Prob FATT=1|INN=1
No	1.3	18.8	20.1	**6.5**	Conditional Prob FATT=1|INN=0
Total	12.3	87.7	100	-	
Conditional Prob. Inn=1	**89.4**	**78.6**			

Bivariate probit$
Less than secondary education

	Increase in Sales		Total		Conditional Prob. Fatt=1
Innovation	Yes	No			
Yes	9.02	16.7	25.72	**35.1**	Conditional Prob FATT=1|INN=1
No	16.6	57.7	74.3	**22.3**	Conditional Prob FATT=1|INN=0
Total	25.62	74.4	100	-	
Conditional Prob. Inn=1	**35.2**	**22.4**			

Secondary education

	Increase in Sales		Total		Conditional Prob. Fatt=1
Innovation	Yes	No			
Yes	25.9	23.7	49.6	**52.2**	Conditional Prob FATT=1|INN=1
No	16.6	33.8	50.4	**32.9**	Conditional Prob FATT=1|INN=0
Total	42.5	57.5	100	-	
Conditional Prob. Inn=1	**60.9**	**41.2**			

Tertiary education

	Increase in Sales		Total		Conditional Prob. Fatt=1
Innovation	Yes	No			
Yes	20.7	51.3	72	**28.8**	Conditional Prob FATT=1|INN=1
No	4.5	23.5	28	**16.1**	Conditional Prob FATT=1|INN=0
Total	25.2	74.8	100	-	
Conditional Prob. Inn=1	**82.1**	**68.6**			

Total

	Increase in Sales		Total		Conditional Prob. Fatt=1
Innovation	Yes	No			
Yes	17.9	24.6	42.5	**42.1**	Conditional Prob FATT=1|INN=1
No	14.9	42.6	57.5	**25.9**	Conditional Prob FATT=1|INN=0
Total	32.8	67.2	100		
Conditional Prob. Inn=1	**54.6**	**36.6**			

& holds constant the following covariates: sole proprietorship; paper, printing and publishing sectors; selling the final product; selling in local markets; lack of training; high participation rate of employees in firm decisions; entrepreneur's previous activities in entrepreneurship; lack of affiliation with a consortium; and lack of connections to the local area and other firms. The continuous variables are equal to the corresponding means. $ All of the covariates at the mean.
Source: Own elaborations with OPIS data

Table 10A Probability (in%) of increase in firm's sales while introducing or not an innovation, in the estimated recursive bivariate probit model. &

Innovation=1
Recursive bivariate probit&
Less than secondary education

	Increase in Sales		Total	Conditional Prob. Fatt=1		
Innovation	Yes	No			***Impact***	***Difference with terziary***
Yes	11.4	59.3	70.7	**16.1**	***15.0***	***9.8***
No	14.7	14.7	29.4	**50.0**		***17.5***
Total	26.1	74	100			
Conditional Prob. Inn=1	**43.7**	**80.1**				

Secondary education

	Increase in Sales		Total	Conditional Prob. Fatt=1		
Innovation	Yes	No			***Impact***	
Yes	13.6	64.8	78.4	**17.3**	***16.1***	***11.0***
No	11.7	10	21.7	**53.9**		***21.5***
Total	25.3	74.8	100			
Conditional Prob. Inn=1	**53.8**	**86.6**				

Tertiary education

	Increase in Sales		Total	Conditional Prob. Fatt=1		
Innovation	Yes	No			***Impact***	
Yes	5.6	82.9	88.5	**6.3**	***5.9***	
No	3.7	7.7	11.4	**32.5**		
Total	9.3	90.6	100			
Conditional Prob. Inn=1	**60.2**	**91.5**				

Total

	Increase in Sales		Total	Conditional Prob. Fatt=1		
Innovation	Yes	No			***Impact***	
Yes	11.2	64.6	75.8	**14.8**	***13.5***	
No	12	12.2	24.2	**49.6**		
Total	23.2	76.8	100	-		
Conditional Prob. Inn=1	**48.3**	**84.1**				

Innovation=0
Recursive Bivariate probit&
Less than secondary education

	Increase in Sales		Total	Conditional Prob. Fatt=1	
Innovation	Yes	No			***Difference with terziary***
Yes	0.8	69.8	70.6	**1.1**	***0.7***
No	2	27.4	29.4	**6.8**	***4.2***
Total	2.8	97.2	100		
Conditional Prob. Inn=1	**28.6**	**71.8**			

Secondary education

	Increase in Sales		Total	Conditional Prob. Fatt=1	
Innovation	Yes	No			
Yes	1.0	77.4	78.4	**1.3**	***0.8***
No	2.0	20	22	**9.1**	***6.5***
Total	3.0	97.4	100		
Conditional Prob. Inn=1	**33.3**	**79.5**			

Tertiary education

	Increase in Sales		Total	Conditional Prob. Fatt=1
Innovation	Yes	No		
Yes	0.4	88.2	88.6	**0.5**
No	0.3	11.1	11.4	**2.6**
Total	0.7	99.3	100	
Conditional Prob. Inn=1	**57.1**	**88.8**		

Total

	Increase in Sales		Total	Conditional Prob. Fatt=1
Innovation	Yes	No		
Yes	1	75	76	**1.3**
No	1.2	22.6	23.8	**5.0**
Total	2.2	97.6	100	-
Conditional Prob. Inn=1	**45.5**	**76.8**		

& holds constant the following covariates: sole proprietorship; paper, printing and publishing sectors; selling the final product; selling in local markets; lack of training; high participation rate of employees in firm decisions; entrepreneur's previous activities in entrepreneurship; lack of affiliation with a consortium; and lack of connections to the local area and other firms. The continuous variables are equal to the corresponding means.
Source: Own elaborations with OPIS data

Table 10B Probability (in%) of increase in firm's sales while introducing or not an innovation, in the estimated recursive bivariate probit model - Innovation is at estimated mean. &

Innovation at estimated mean
Recursive bivariate probit&
Less than secondary education

	Increase in Sales		Total	Conditional Prob. Fatt=1	
Innovation	Yes	No			***Difference with terziary***
Yes	5.3	65.4	70.7	**7.5**	***3.0***
No	9.2	20.2	29.4	**31.3**	***5.6***
Total	14.5	85.6	100	-	
Conditional Prob. Inn=1	**36.6**	**76.4**			

Secondary education

	Increase in Sales		Total	Conditional Prob. Fatt=1	
Innovation	Yes	No			
Yes	7.9	70.4	78.3	**10.1**	***5.6***
No	8.5	13.1	21.6	**39.4**	***13.9***
Total	16.4	83.5	100	-	
Conditional Prob. Inn=1	**48.2**	**84.3**			

Tertiary education

	Increase in Sales		Total	Conditional Prob. Fatt=1
Innovation	Yes	No		
Yes	4	84.6	88.6	**4.5**
No	2.9	8.5	11.4	**25.4**
Total	6.9	93.1	100	-
Conditional Prob. Inn=1	**58.0**	**90.9**		

Total

	Increase in Sales		Total	Conditional Prob. Fatt=1
Innovation	Yes	No		
Yes	6.2	69.6	75.8	**8.2**
No	8.5	15.7	24.2	**35.1**
Total	14.7	85.3	100	-
Conditional Prob. Inn=1	**42.2**	**81.6**		

& holds constant the following covariates: sole proprietorship; paper, printing and publishing sectors; selling the final product; selling in local markets; lack of training; high participation rate of employees in firm decisions; entrepreneur's previous activities in entrepreneurship; lack of affiliation with a consortium; and lack of connections to the local area and other firms. The continuous variables are equal to the corresponding means.
Source: Own elaborations with OPIS data