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The determinants of innovation: What is the role of risk?

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Abstract

Because of its importance in understanding and explaining growth, the topic of innovation has received a huge attention in the economic literature. However, our knowledge of the factors that influence innovation and its related activities is not as exhaustive as it could be. The present study aims at contributing to analyse the determinants of innovation, with a special focus on firm risk. Employing a rich sample of Italian manufacturing firms, we tested for the impact on innovation of the riskiness of the firm, as proxied by the probability of default. We found that riskiness of enterprise reduces the tendency to innovate for the firms. The main channel through which firm risk affects innovation capability appears to be that of innovation financing.

Key words: Technological Change; Financial Risk and Risk Management

JEL Classification: O3; G32

1 Introduction

The total cost of innovation is considered one of the determinant factors for achieving sustainable economic growth. This explains the great concern

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with the topic of innovation in economic literature. Possible determinants of innovation have been analyzed in a significant number of both theoretical and empirical studies.[1] However, our knowledge of the factors that influence innovation and its related activities is not as exhaustive as it could be. The process toward innovation is not as linear as it should be, as the different variables that are expected to determine and incentive innovation are so numerous that the problem of omitted variables is very likely to influence the interpretation of empirical studies.

The factors influencing innovation can be both of an internal or an external nature. The former can include features such as age, size, and being a member of a certain group; strategic features, such as the presence on foreign markets; financial features as the solidity of a firm and its relationship to the banking system. Among the latter there can be the level of competitiveness of the market, its socio-economic structure and the financial situation of a country.

The present study aims at contributing to analyse the determinants of innovation, with a special focus on firm risk. Theoretical literature on innovation does not offer unequivocal predictions about the effects of firm risk on innovation capability. One of the main reasons is the difficulty of accurately defining the concept of risk. Risk and uncertainty are, in fact, typical features of all entrepreneurial activities; hence, various firm risk factors can have contrastive effects on the probability of innovation. For this reason, while analysing various sources of firm risk, we combine these factors in a single model allowing us to study the overall effect on firm innovation capability. The measure we employ is one-year default probability of a firm.[2]

This analysis is carried out by examining a wide sample of Italian manufacturing businesses. The empirical model employed aims at verifying the main innovation determinants, starting with the results obtained in the literature and subsequently inserting the firms' one-year probability of default in order to study the impact of risk on firm innovation capability.

The results show that firm risk reduces the tendency to innovate. Moreover, the size of a firm, its inclusion in a consortium, its export tendency and the level of diversification, are all relevant for determining its innovation capability.

[1] See for example Cohen and Levin (1989) and Cohen (1995).

[2] Firm default probability allows us – by integrating in a single model all the different factors of risk (such as cash flow volatility, technological risk, demand uncertainty etc.) – to assess empirically the impact of risk on the innovation probability of a firm.

The rest of this paper is organized as follows. Section 2 presents a detailed review of the literature on the determinants of innovation. Section 3 is devoted to present the data set we use, explaining also our econometric strategy. In section 4 we show our main results and robustness checks. Section 5 concludes the paper.

2 Background literature

In the existing literature, the impact of firm risk on innovation capability has not been studied comprehensively. The available works analysed only the impact of single aspects of firm risk. After a presentation of these works, we consider other possible innovation determinants, which are empirically analysed in order to isolate the impact of risk.

2.1 Risk

The relation between riskiness of firm and innovation is related to the literature that study the best way to finance innovation. This strand of literature is very important, because a central problem in the managing of technology is the financing of technological development and innovation. Schumpeter (1942) asserted that the innovation process is best financed through internal finance (what he called monopolist profits). Furthermore, Himmelberg and Petersen (1994) found empirical evidence that good internal financial conditions are likely to increase innovation. The reasons of the crucial role of internal finance in financing innovating firms are to be found in the literature about information asymmetries.

Some studies show that the riskiness of firm affects the amount of investments, especially the investments meant for innovation. These results are true in particular for the firm's cash flows volatility.[3] In fact, a higher cash flow volatility implies that a firm is more likely to have periods of internal cash flow shortfalls. The analysis of Minton and Schrand (1999) indicates that firms do not simply react to shortfalls by changing the timing of discretionary investment to match cash flow realizations. Rather, firms forgo investment. Furthermore, empirical studies show greater volatility of cash

[3] Garcia-Vega and Guariglia (2007) predicted that more volatile firms are more likely to go bankrupt and need to be more productive to stay in the market.

flows is positively linked with a higher cost of access to external finance. Finally, different authors (Gibbins et al., 1990; Chaney and Lewis 1995, and Fudenberg and Tirole, 1995) have insisted on the adverse reputation effects of high earnings volatility for firms and their managers.

However, the chief way in which firm risk affects innovation capability is that of the access to external capital. As a matter of fact, not all firms are able to finance their innovation projects by drawing on internal cash flows. Hall (2002) demonstrated that small businesses and start-ups presented major problems when it came to investing in new technologies. In these cases, the companies were forced to deal with asymmetric information problems, typical of the relationship between businesses and the financial sector, which increased in the case of funding for innovative projects. Indeed, banks are unable to fully distinguish between their customers, since they do not have the necessary information to evaluate either the quality of the project or the risk of opportunistic behaviour by the counterparties (Rajan e Zingales, 2001). In a similar context it is probable that the bank is wary of the default probability of the firm it is dealing with. Thus, we can predict that the companies with higher default probability are less likely to carry out innovative projects.

2.2 The main determinant of Innovation

The literature on innovation built a theory focusing on several possible determinants of innovation, whose role is often not unanimously accepted. In particular, the factors influencing innovation activities can be divided in internal and external.

As for internal factors, size is one of the possible determinants of innovation which is not unanimously accepted. Schumpeter (1912) argued that small firms were the best at innovating. With a decided turn with respect to his previous views, Schumpeter (1942) argued that monopoly could be a spur to research and development. According to Scherer (1992), even though there is evidence that small firms are rich in innovating ideas, generally the flux of innovation comes from large, well established enterprisers, operating in open markets, where the possibility of innovation itself stimulates the overall innovation. In general, most theorists argue that size is a relevant factor in innovation for several reasons: i) research and development (R&D) projects typically involve large fixed costs (such as investments in human capital) which can be covered only if sales are sufficiently large; ii) R&D features involve economies of scale and scope in the production of innovations; iii) large and diversified firms can absorb better the losses determined by economically unprofitable projects; iv) large firms can undertake many projects at any one time and hence reduce the risks of R&D.

Furthermore, some empirical works show evidence of a threshold effect of firm size on R&D activity (Greer and Rhoades, 1976; Shrieves, 1978). On the other hand, there are both theoretical and empirical studies that argue the opposite thesis: Acs and Audretsch (1987, 1990) show how in smaller firms (less than 100 employees) innovation per worker is higher than in larger firms; Pavitt et al. (1987) found that innovation is more likely to come from large firms and small firms than from medium-sized and very small firms.

Another factor to study is the efficiency of the firm. Higher efficiency implies a higher return both for a mature and a new technology. This means that the entrepreneur can pledge more expected returns given innovation. However, if the new technology is exposed to the bank's hold-up, a higher asset value will increase the outside option of the bank in a renegotiation of the initial contract, exacerbating the bank's rent extraction (Rajan, 1992). Hence, higher efficiency does not necessarily render innovation more appealing.

About the impact of the bank's hold-up on innovation, Minetti (2004) shows that in an economy with limited contract enforceability, informed finance can inhibit technological progress to slow down the depreciation of its information on mature technologies.

A measure of size considered among the determinants of innovation is the number of countries in which the firm operates. Petersen and Rajan (1997) found that geographic expansion preceded increased spending in R&D, while an high level of R&D spending did not precede expansion. The increase in international competition that firms face, could be an incentive to innovate.

Let us turn now to consider the external factors affecting a firm's ability to innovate. The first one is the socio-economic structure of the country in which the firm operates. Socio-economic structure is generally considered an important source of incentives for innovation and firm development. An important question about local conditions is: does local financial development impact on innovations? Does financial integration provide means to outdo possible local financial backwardness? Quite obviously, both theory and evidence show that agents established in regions characterised by well developed financial systems have more and better possibilities to get external finance. Furthermore Guiso et al. (2004) have demonstrated that even if the financial market is integrated, the role of local differences remains important. The effects of these evidences are more important as the size of the firm decreases: small firms have really little chances to obtain finance from far located financial institutions. Both Berger et al. (2001) and Petersen and Rajan (2002) found that small firms are less likely to borrow from distant banks, which makes them more dependent on the level of local financial development.

A crucial topic in theoretical literature on innovation, such as Aghion and Howitt (1998), relates to the probability that the firm faces an innovation opportunity, as induced by factors outside the firm's control. The main example are knowledge spillovers among firms in the same industry or among firms that belong to a group or consortium.

Finally, it is important to underline the role of market structure. The literature on endogenous growth theory confirms the results in Schumpeter (1942). For example, Aghion and Howitt (1998) showed how in a market characterised by increased competition, incentives to research by firms are reduced. Murro (2007) showed how, in a more competitive market, the effectiveness of a public policy designed to encourage innovation is reduced by means of a direct commitment in the field of basic research.

2.3 Product innovation and process innovation

In the existing literature there is not always a clear distinction between innovation on the one hand and R&D spending on the other: the two concepts have often been juxtaposed. However, in recent years, many empirical studies have analysed the relationship between R&D spending and the results in terms of firm innovation. In fact, R&D spending – though essential for the innovation activities of a firm – is only one of the elements that drive the creation of new products, or the invention of new production processes. Parisi et al. (2006) estimated the effect of R&D spending on both product and process innovation by using the same survey employed in this work.[4] The results obtained showed that investment in research and development was positively associated with the introduction of product innovation. Slightly different are the results regarding process innovation. In fact, R&D spending was not per se significant for explaining the introduction of process innovation, unless it was made to interact with the investments made. The authors

[4]Parisi et al. (2006) used the sixth and the seventh editions of *Indagine sulle Imprese Manifatturiere italiane*; we used the seventh, eight and ninth editions.

interpreted these results by claiming that R&D spending allowed the firm to absorb the investments in new technologies. This result is consistent with numerous works demonstrating that research – apart from directly stimulating innovation – facilitates the absorption of new technologies.[5]

The contrasting results between product innovation and process innovation show the different natures of the two innovation types. Cohen and Klepper (1996) modelled the differences between the two types of innovation, underlining the different incentives that spurred companies to embark on product or process innovation. Process innovation reduced production costs, whereas product innovation increased the price that consumers were willing to pay. Accordingly, different factors can have different effects on the two innovation types. Different incentives also play a role in the way these activities are funded. It is this difference which is most interesting in our context. Cohen and Klepper (1996) showed that firms tended to finance process innovation, rather than product innovation, by means of internal cash flow. This result is confirmed by Herrera and Minetti (2007), who show that the positive impact of the length of the relationship between bank and firm is somewhat stronger for product than for process innovations. They propose two explanations for this result. The first relates to the fact that product innovations can be more resource-demanding than process innovations because they require larger purchases of new equipment. The second relates to the role of secrecy, which is thought to be more important for process than for product innovations.

Different ways of funding lead to a different impact of risk on innovation. If external financing is considered the main channel through which firm risk affects innovation capability, then the type of innovation which requires less external financing will be less susceptible to risk.

3 Empirical methodology and data

3.1 The empirical model

The aim of this paper is to investigate if the probability of default of the firm influences firms to undertake and realize innovative projects. To do this we model the innovation choice of the firm. Denote by y_1^* the pledgeable expected return of the new technology net of the bank's opportunity cost of funds.

[5]See also Romer (1990), Grossman and Helpman (1991) and Griffith et al. (2004).

Denote by y_2^* the return that the entrepreneur expects to appropriate from the new technology net of the expected return from the mature technology. The above analysis implies that the firm innovates if $y_i^* = min(y_1^*, y_2^*) > 0$. Thus, the firm's decision to innovate can be modeled as:

$$y_i = 1(y_i^* > 0) \tag{1}$$

$$y_i^* = a_1 x_i + z_{i1} d_{11} + u_{i1} \tag{2}$$

with $i = 1, .., n$ and where y_i is a measure of the innovation choice, a dummy variable that takes on a value of one if the firm innovates and zero otherwise, x_i is a measure of the probability of default, z_1 denotes a matrix of controls, and u_{i1} is the residual ($u_{i1} \sim N(0, \sigma^2)$) in the "innovation equation" (2).

Generally, a_1 could be interpreted as the response of the firm's innovation choice to x_i. However, there are a potential problem with this interpretation. The determination of x_i can be endogenous to the innovation choice y_i. In fact, as some straightforward theoretical contribution on financial imperfections and credit rationing stressed[6], investments in R&D and, in general, in innovative projects are characterised by a considerable high degree of uncertainty. In fact, the conspicuous amount of investments required to sustain innovative projects, the high mortality rate of those projects and the time to market are factors that increase the level of the firm's risk. Furthermore, the high level of idiosyncrasies connected to innovative projects worsens the asymmetric information issues between firms and credit institutions, thus fuelling credit rationing phenomena.

We correct these problems using a two-stage estimation approach. We define z_{i2} as a matrix of instrumental variables that are correlated with the riskiness of the firm, but affect the innovation decision only through the effects on the probability of default. The effect of these instruments on x_i is captured by d_{22} in the "riskiness equation":

$$x_i = z_{i1} d_{21} + z_{i2} d_{22} + u_{i2} \tag{3}$$

where z_{i1} refers to the control variables in (2), z_{i2} is the matrix of instruments, and u_{i2} is the residual ($u_{i2} \sim N(0, \sigma^2)$). We estimate the model

[6] See among others: Himmelberg and Petersen (1994) found a strong relationship between R&D investments and cash flows; Guiso (1998) demonstrated a link between high tech firms and credit rationing; Savignac (2006) investigated the impact of financial constraints on innovation.

(1)–(3) using two methods: two-stage least squares (2SLS) and two-stage conditional maximum likelihood (2SCML). The 2SLS estimation amounts to assuming that the probability of innovation is linear in the parameters a_1 and d. Although this linear probability model usually works well for values of the explanatory variables that are close to the sample average, it suffers from two limitations. First, for certain combinations of the explanatory variables, the predicted probabilities can be greater than one or less than zero. Second, the partial effect of any explanatory variable, expressed in levels, is restricted to be constant. To overcome these limitations, we also estimate the model (1)–(3) using the 2SCML technique. We show also the results of model (1)-(2), estimated with the maximum likelihood probit model.

3.2 Data description

Our data are taken from four sources: 1) the three-yearly *Indagine sulle Imprese Manifatturiere italiane* (Survey of Italian Manufacturing Firms, SIMF) runs by Capitalia (Mediocredito Centrale) for the periods 1995-1997, 1998-2000 and 2001-2003; 2) the one-year probability of default calculated using the Moody's KMV RiskCalc^{TM} Italy, released in October 2002; 3) data on the value added and population of provinces from the Italian National Statistics Office (ISTAT); 4) data on the presence of banks in local markets from the Bank of Italy.

The SIMF collects data, on a three-year basis, from about 5,000 Italian firms with more than ten employees. All the firms with more than 500 employees are included, while those having a number of employees in the range 11 to 500 are sampled according to a stratified selection procedure based on their size, sector, and geographic localization. The strength of our dataset lies in the highly firm-specific data and time coverage (three surveys in nine years). Particularly, it contains information about: a) ownership structure, b) number and qualification of employees, c) R&D investments, R&D funding and innovation produced, d) internationalization degree and export, e) financial data, relationship with banks and credit rationing. This information is gathered through a survey on the three years previous to the survey year. The firms analysed in the three surveys represent about 9% of the population in terms of employees and 10% in terms of added value.

This survey aimed at providing the strategic information to the banking group, while striving to propose the policies for the promotion of firm competitiveness. Over the years, this survey has proved a fertile field for research:

for example, Detragiache, Garella, and Guiso (2000) used it to analyse the types of indebtedness of Italian companies, and Herrera and Minetti (2007) studied the impact of relationship lending on firm innovation capability.

In our analysis, we used the dataset in several different ways. First, considering partial temporal coincidence between the survey data and the data on the default probability of the firms, we took into account only the 4289 firms from the most recent survey (2001-2003). Next, a different risk variable, one deriving from the balance sheet data, was used in order to test the robustness of the results. This enabled us to use the observations of each survey. In this case, there were 13466 observations. The firms present in more than one survey were repeated. In those cases where the annual variables of a firm, such as balance sheet entries and the number of employees, were available, we took into account the mean of the period under consideration. Finally, in order to study the variability among firms, a data panel study was carried out, taking into account only the 644 firms present in all the three surveys. See Table 1 for the definitions of the variables.

In Table 2 we reported summary statistics for each survey. Geographic distribution of the firms revealed a clear preponderance of firms from Northern Italy (more than 65% of the total), while other firms were based equally in the Centre and South (with a slight majority in the Centre). The distribution among sectors, defined according to Pavitt's taxonomy, showed the preponderance in all the surveys of businesses pertaining to traditional manufacturing sectors, amounting to almost a half of the sample (this percentage was lower only in the 1995-1997 span, amounting to 42%). The portion of high technology firms was very low, failing to exceed 5% of the sample. The average dimension of the firms, measured according to the number of the employees, was small to medium. A comparison among the different surveys showed that the medium size of the businesses varied considerably: in the first survey under consideration, the average number of the employees equalled 114; in the second survey it decreased to 86; in the third it equalled 138 employees. Another significant variable was that of the firms' net sales, which decreased from 515,000 euro in the first survey to 379,000 euro in the most recent one. More stable was the average firm age, slightly exceeding 20 years (23 years for the two earlier surveys, 28 for the most recent one).

3.3 Variables

In this paper we use a direct measure to study *innovation*. The survey asks each firm, "In the last three years, did the firm realize product innovations, process innovations, organizational innovations related to product innovations, organizational innovations related to process innovations?" Thus, we can define three binary variables that take on a value of one if the firm innovated and zero otherwise: (a) INNOVATION, if firm realizes whichever type of innovation; (b) INNOPROD, if firm realizes product or related organizational innovation; and (c) INNOPROC, if firm realizes process or related organizational innovation. As shown Table 2, the percentage of the innovative firms varied significantly in the three surveys. Indeed, in the first survey 75% of the firms had made some type of innovation; in the second survey this percentage decreased to 53%, whereas in the third survey it grew to 62%. The distribution according to the innovation type varied as well. In the first survey, 68% of the firms made process innovations while 31% of the firms carried out product innovations. In the span covered by the second survey, however, the percentages of the two types of innovation were almost equal: 26% of the firms carried out product innovations, while 27% made process innovations. In the last survey, the firms carrying out product innovations were by far more numerous (42%, while only 20% carried out process innovations).

Table 3 provides details on the distribution of innovative firms across two-digit ATECO sectors. Among industries with more than three observations, Electronic and Computing equipment has the highest rate of product or related organizational innovation (57.4%), followed by Medical Equipment and Communication Equipment (43% and 42.7%). The two industries with the highest rate of process or related innovation are Primary Metal Products (49.5%) and Paper (46.1%). Thus, while firms in high-tech sectors engage more in product innovations, firms in traditional sectors engage more in process innovations.

In assessing *firm risk* we used as a variable the probability of default of the firm. This choice was determined by the fact that the probability of default represents a good synthesis of various factors that make a company risky. Apart from decisively influencing the decisions of the firm's sponsors, this information is also the most easily available one. Two methodologies were used in order to evaluate the default probability of a firm. The first one is Moody's KMV RiskCalc Italy model, which calculates the probability of a firm not being able to repay its financial debt in the following year. This model employs following financial variables: profitability, financial leverage, debt coverage, liquidity, activity, size (see Table 4 for a detailed description). Unfortunately, the dataset available in this model only partially coincided with the one we used. As a matter of fact, Moody's started the evaluations of Italian companies only in 2002; this is why in using this variable, we only took into account the most recent survey at our disposal. Among the robustness checks of the results, we used another measure for evaluating firm risk: the Z-score. This formula, first proposed by Altman (1968), measures a firm's financial solidity correlated to the two-year default probability.[7] This variable, based on the balance sheet data, allowed us to use all the data at our disposal, enabling us to carry out a robustness check of our main hypothesis for the whole period under consideration.

The reason we were led to use Moody's RiskCalc model as the principal measure in assessing risk, despite the lack of the data for the period before 2002, is the greater accuracy of this model. Indeed, as explained by Kogacil et al. (2002), the RiskCalc model predicts firm default much better than the Z-score.

As *control variables*, we used the ones generally considered to determine innovation. The analysis of paragraph 2.2 suggests that innovation is a function of some variables typical of the firm, and of the variables characteristic of the market in which it operates. Among the features of a firm, one of the main factors to be taken into consideration is its size. We used the logarithm of the number of employees as a proxy for size. Same results would be obtained if the logarithm of the firm's net assets were used as a size variable.

Another factor bearing on the decision to innovate is a company's intrinsic efficiency. Following Herrera and Minetti (2007), we examined this factor in two ways. The first is the analysis of the workforce composition. We inserted two variables indicating the percentage of the employees with a secondary school diploma and the percentage of those with a university degree. Furthermore, we inserted a dummy variable that took the value of 1 where

[7] The Z-score formula for non-listed companies is as follows:
$Zscore = 0.717T_1 + 0.847T_2 + 3.107T_3 + 0.42T_4 + 0.988T_5$, con T_1= (Current Assets - Current Liabilities) / Total Assets; T_2= Retained Earnings / Total Assets; T_3= Earnings Before Interest and Taxes / Total Assets; T_4 = Book Value of Equity / Total Liabilities; T_5 = Sales / Total Assets. The Z-score can be seen as a measure of financial soundness of the firm which is correlated to the probability of default in the two following years. The higher its value, the smaller the probability of default.

the firm in question had ISO9000 certificate attesting the production process efficiency and the product quality. Two remaining characteristics taken into account were age (its logarithm) and the quota of the majority shareholder.

In order to examine the possibility of knowledge spillovers, we inserted a dummy taking the value of 1 where the firm was part a consortium. As the variable determining the firm's international presence, we used the answer to the question whether the firm had exported its products in the last year considered in the survey. Moreover, in order to assess the competitiveness of the market in which the firm in question operated, we inserted the dummy variable taking the value of 1 if the firm faced international competition.

Another relevant factor taken into account was the level of the firm's diversification. A more diversified firm has more opportunities to exploit scope economies deriving from innovation. Plausibly, the higher the number of industries in which the firm is active, the more diversified is the firm. In order to examine this factor we code dummy variables for whether the firm is classified in a three-, four-, or five-digit ATECO sector (as in Herrera and Minetti, 2007).

With regards to the characteristics of the environment in which the firm operated, we took into account first of all the geographic location. More specifically, we inserted two dummy variables if the firm was located in Central or Southern Italy. These factors are of consequence due to the pronounced diversity of the Italian macro-areas (the North, the Centre and the South), both in terms of infrastructure and social capital. Next, in order to evaluate the impact of the economic environment of the firm, we verified the average rate of annual growth of the provincial added value (for the years 1989-1998), the level of the regional financial development, as measured in Guiso et al. (2004), and the average of the Herfindahl-Hirschman Index on total bank lending in the province (from 1990 to 2006).

Finally, we divided the businesses into sectors on the basis of the categorisation proposed by Pavitt. Pavitt's taxonomy refers to four patterns of industrial firms: *supplier dominated* (including firms in traditional manufacturing sectors), *scale intensive* (sectors characterized by the use of consolidated technologies and highly standardized processes), *specialized suppliers* (SMEs producing machinery or components catering to the needs of firms from other sectors), *science based* (medium to large firms from sectors with a high degree of R&D). We inserted three dummy variables for the last three sectors in this classification.

In order to solve the problem of endogeneity between the choice to innovate and firm risk, we used a two-stage approach. As *instrumental variable* of firm risk we used the percentage variation in workforce. This variable – specific to all firms – is a good risk proxy, since a firm will probably decide to adapt its workforce to the future outlook, despite the inflexibility of the Italian labour market. Moreover, there is no reason to believe that workforce variation influences a firm's decision to innovate.[8]

4 Results

The results of the evaluation of innovation determinants are presented in Table 5. They show that firm risk significantly reduces the likelihood of innovation by the firm. Due to the endogeneity of default probability, we also estimated the model using 2SLS (two-stage least squares) and 2SCML (two-stage conditional maximum likelihood) methods.

Table 6 shows the results of the first stage of 2SLS. The Durbin test enabled us to exclude the null hypothesis of exogeneity of variables.

Analysing the impact of the instrument on risk, it was be observed that the percentage variation in workforce was negative. Predictably, the less risky firms were those that could allow themselves an increase in workforce. Commenting on the effects of the remaining variables, it can be observed that size, age and efficiency (assessed on the basis of ISO9000 certificate) had a negative effect on firm risk, whereas a larger quota by the majority shareholder, geographic position and the inclusion in a high tech sector increased firm risk.

Table 7 shows the estimates of both instrumented models. We will comment on the results of 2SCML model, since the 2SLS estimates are qualitatively analogous. These models confirmed the significance of risk in explaining the firm's choice to innovate. The marginal effect of instrumented estimation proved to be much higher than the basic Probit estimation.

When other innovation determinants were verified, the results confirmed the previously discussed theoretical predictions. The size of the business – measured according to the number of people employed – had a positive effect on the likelihood of innovation. The international presence had a role in

[8] We can believe that the percentage variation in workforce may influences a firm's decision to innovate if the firm hires high-skilled workers. In our data, the average percentage of graduates among the new workers is 6%, and only 5% of all firms hired a percentage higher than 33% of graduates.

driving innovation. In fact, the firms reporting they exported had a greater probability of innovation than those that did not export. As regards firm efficiency, the workforce composition affected the probability of innovation, while having ISO9000 certificate did not prove statistically significant. The percentage of the employees holding a university degree appeared quite relevant and had – with the exception of risk – the highest marginal effect among innovation determinants. Firm age affected innovation negatively.

Another aspect we verified is the effect of the possibility of knowledge spillovers among the same-sector businesses and the businesses in a consortium. The results confirmed the importance of spillovers in creating innovation opportunities. Indeed, the firms that were part of a consortium have a 0,08 higher probability of realizing innovation than the others. Moreover, an exam of Pavitt's sectors showed that belonging to a high technology or a highly specialized sector increases innovation probability.[9]

A firm's diversification level proved to be statistically significant. The strongest marginal effect was that of 4-digit ATECO businesses. The presence of international competition was not significant, which contradicts the theoretical results on the importance of the competitiveness of the relative market. The reason is probably the scant efficacy of the variable used as a proxy for the level of market competitiveness.

Among the factors external to the company, the regional development rate as the level of bank concentration proved to be significant, whereas geographic location and the annual growth of the provincial added value were not statistically significant.

To verify our hypothesis that external financing is the main channel whereby firm risk affects innovation decisions, we carried out two tests. Primary we analysed the impact of risk on product and process innovation. After – to test for the need of external finance – we split the sample in two groups: the first one made up by the small firms (the firms that have a number of employes inferior to the median); the second group included the big firms.

We observed in section 2.3 that the literature considered the possibility that some factors affect differently product innovation and process innovation. This is why we analysed the impact of risk on both types of innovation.

[9]Verifying two-digit ATECO industries, there are few significant sectors. Particularly significant, while showing a negative effect on innovation probability, are certain traditional sectors, such as Food Lumber and Printing and Publishing.

Tables 8 and 9 show the results for product and process innovation respectively.[10] We relate the three methods of evaluation we used, since, especially with regards to process innovation, the hypothesis of the endogeneity of risk is to be excluded. The results of this evaluation showed a clear difference between the two types of innovation. Whereas the results concerning product innovation were confirmed, albeit with a lower significance level, process innovation appeared independent of firm risk. In fact, in no case did the one-year probability of default appear significant, according to none of the three evaluation methods.

This result – supported by the predictions in the theoretical literature, according to which product innovation is more dependant than process innovation on external financing – confirms the interpretation offered for the impact of risk on innovation probability. If external financing is considered the main channel whereby firm risk affects innovation decisions, it is predictable that process innovation should be less dependant on risk.

As far as other innovation determinants are concerned, the results for each innovation type vary. With regards to product innovation, the results obtained were similar to those regarding innovation in general. The only differences were those determined by the membership in a consortium (which is not more significant for this type of innovation) and by the level of diversification, which looses its significance (except in the case of 4-digit ATECO level).

Some results related to process innovation differed from the estimates so far considered. In order to explain process innovation, both the ISO9000 certificate (which had positive value) and the presence of international competition were significant. The latter decreased the probability of achieving process innovation. On the other hand, the workforce composition, regional financial development, the level of diversification and the age of the firm were not significant.

A further partial confirmation of our hypothesis was provided by the check carried out by dividing the sample in two groups according to the dimension of the firm. The results of this estimate, presented in Table 10, show that for the big firms the marginal effect of RISK is not significant (2SCML estimate).

We carried out a robustness check by using another variable evaluating

[10] We used wider definitions of product innovation and process innovation: they refer both to product (process) innovation proper and to organizational and managerial innovation related to product (process) innovation. The results obtained if organizational and managerial innovation is excluded are qualitatively identical.

firm risk. The variable in question is Z-score, which measures a firm's financial solidity by using its balance data. Though less accurate than RiskCalc model in calculating firm default probability, it has the advantage of being available for all the years covered by the surveys. In this way, apart from testing the robustness of the results when the variable used as the index of risk was changed, we were able to verify whether our results depended on the Survey employed.

This check was carried out in two phases. In the first phase we examined all the firms by a pooled estimate (with specific temporal variables of the surveys); then, we employed a panel estimate in order to verify the variability among firms. We will present instrumented estimates directly, since the problem of endogeneity is particularly difficult in this model specification.

Table 11 presents the estimate which takes into account the time effects. The main result was confirmed by this check. A company's Z-score is significant for explaining innovation. There is a positive correlation, since this variable measures a firm's financial solidity, so that a higher Z-score implies a lower firm risk.

With regards to other innovation determinants, almost all the variables which proved significant in the basic model were significant in this specification, the exceptions being the variables pointing to firm diversification, sector variables, the level of the concentration of the banking sector and the level of financial development of the region where the firm had its headquarters.

Finally, some variables which were not significant in the basic estimate were significant in this one. Specifically, the ISO9000 certificate were shown to increase the innovation probability of a firm. The geographic location of a firm deserves a special mention. If a firm was located in the South, it was more likely to innovate. This result contradicts the theoretical predictions.

Table 12 shows the results of the panel estimate. In running this test we considered only the 644 businesses present in all the surveys. As regards the other variables, almost none of them was significant, except for firm size, the inclusion in a consortium, the percentage of the employees holding a university degree and the inclusion in a specialized sector. All these variables had the same sign as the basic model.

5 Conclusions

Because of its importance in understanding and explaining growth, the topic of innovation has received a huge attention in the economic literature. Employing a rich sample of Italian manufacturing firms, we tested for the impact on innovation of the riskiness of the firm, as proxied by the one-year probability of default. We found that riskiness of enterprise reduces the tendency to innovate for the firms.

The main channel through which firm risk affects innovation capability appears to be that of innovation financing. When firms are unable to finance autonomously their innovation projects, they are forced to apply for external funding. However, due to asymmetric information problems, even more evident in the case of innovative companies, banks can evaluate neither the quality of the project nor the possibility of opportunistic behavior by counterparties. In a similar context, the firms with higher default probability will hardly be able to finance their innovation.

This process is confirmed by the fact that the incidence of risk is focused on product innovation, the type of innovation most dependant on bank funding. Moreover, the results show that smaller firms are more vulnerable to the consequences of default probability.

The results obtained also show that the size of a firm, the international presence, its efficiency level, the level of technology of the industry where the firm operates and whether the firm belongs to a consortium, play a conspicuous role in determining innovating activities. All of these results are in line with what is said in the specific literature, where those factors are considered crucial variables.

Our evidence might warrant some policy considerations. The link between firm risk and innovation may reduce the capability for economic system to emerge from crisis periods. Indeed, if innovation is one of the solutions to the difficulties for enterprises, the negative effect of risk on innovation is like to reduce possibility of recovery. A more accurate study of the channel trough which firm risk affects innovation capability seems necessary. As to future research, our paper suggests developing a theoretical model featuring the transmission mechanism between risk and innovation.

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Appendix

Table 1: Variable Definitions

Variables	**Definitions**	**Sources**
Dependent Variables		
INNOVATION	Dummy variable that take on a value of one if the firm innovated	SIMF
INNOPRODUCT	Dummy that takes the value one if the firm introduced product or product-related organizational innovations	SIMF
INNOPROCESS	Dummy that takes the value one if the firm introduced process or process-related organizational innovations	SIMF
Endogenous Variables		
RISK	One year probability of default calculated by Moody's KMV $RiskCalc^{TM}$ Italy	Moody's
Zscore	Measure of firm's financial solidity	SIMF
Control Variables		
EMPLOYEES	Average of the number of employees	SIMF
SIZE	Logarithm of the number of employees	SIMF
EXPORT	Dummy variable that take a value of one if the firm exports	SIMF
CONSORTIUM	Dummy taking the value of one if the firm was part a consortium	SIMF
NORTH	Dummy that takes the value one if the firm was located in North Italy	SIMF
CENTER	Dummy that takes the value one if the firm was located in Central Italy	SIMF
SOUTH	Dummy that takes the value one if the firm was located in Southern Italy	SIMF
Lower Secondary	Percentage of the employees with a lower-secondary school diploma	SIMF
Secondary education	Percentage of the employees with a secondary school diploma	SIMF
Graduates	Percentage of the employees with a university degree	SIMF
GROWTH	Average rate of growth of value added in the province	SBBI
SHARE	Percentage of equity held by the largest owner	SIMF
ISO9000	Dummy variable that takes the value of one if the firm is ISO9000 certifed	SIMF
International Competitors	Dummy variable that takes the value of one if the firm faced international competition	SIMF
HHI	The Herfindahl-Hirschman Index on total bank lending in the province in 1991-1998	SBBI
RFD	The level of the regional financial development, as measured in Guiso et al. (2004)	GSZ (2004)
AGE	Age of firm since foundation, in logarithmic of years	SIMF
Diversification-3 digit	Dummy that takes the value one if firm has a 3 digit ATECO classification	SIMF
Diversification-4 digit	Dummy that takes the value one if firm has a 4 digit ATECO classification	SIMF
Diversification-5 digit	Dummy that takes the value one if firm has a 5 digit ATECO classification	SIMF
TRADITIONAL	Dummy that takes the value one if the firm is in traditional manifacturing sectors	SIMF
SCALE	Dummy that takes the value one if the firm is in sectors with highly standardized processes	SIMF
SPECIALIZED	Dummy that takes the value one if the firm is in SPECIALIZEDalized manifacturing sector	SIMF
HIGH TECH	Dummy that takes the value one if the firm is in sectors with high degree of R&D	SIMF
LIQUIDITY	Logarithm of the firm's liquidity	SIMF
Insteumental Variables		
Δ LABOUR	Average percentage variation in workforce	SIMF

In this Table we report the definitions and the sources of the variables. Two main data sources are used in the empirical analysis: the Surveys of Italian Manufacturing Firms (SIMF) and the Statistical Bulletin of the Bank of Italy (SBBI).

Table 2: Summary statistics

	1995-1997						1998-2000						2001-2003					
	Mean	S.E.	Percentile				Mean	S.E.	Percentile				Mean	S.E.	Percentile			
			25%	50%	75%	95%			25%	50%	75%	95%			25%	50%	75%	95%
INNO	0.751	0.432	1	1	1	1	0.532	0.499	0	1	1	1	0.620	0.498	0	1	1	1
INNO PRODUCT	0.318	0.465	0	0	1	1	0.260	0.438	0	0	1	1	0.421	0.493	0	0	1	1
INNO PROCESS	0.681	0.466	0	1	1	1	0.271	0.444	0	0	0	1	0.198	0.399	0	0	0	1
Z SCORE	2.091	0.654	1.65	2.04	2.47	3.19	2.081	0.668	1.61	2.04	2.49	3.21	2.014	0.701	1.56	1.96	2.39	3.09
RISK	0.009	0.016	0.002	0.004	0.008	0.02	0.011	0.021	0.002	0.005	0.01	0.03	0.011	0.020	0.002	0.004	0.01	0.03
EMPLOYEES	114.2	321.8	20	33.3	79.3	434	86.52	375.1	17	24	45.6	327	138.1	398.6	22.6	48	104	546
SIZE	3.827	1.099	2.99	3.50	4.37	6.07	3.510	1.002	2.83	3.17	3.82	5.78	4.027	1.140	3.12	3.87	4.64	6.30
EXPORT	0.659	0.473	0	1	1	1	0.673	0.469	0	1	1	1	0.683	0.465	0	1	1	1
CONSORTIUM	0.100	0.300	0	0	0	1	0.101	0.301	0	0	0	1	0.124	0.330	0	0	0	1
NORTH	0.700	0.458	0	1	1	1	0.649	0.477	0	1	1	1	0.661	0.473	0	1	1	1
CENTER	0.172	0.378	0	0	0	1	0.206	0.404	0	0	0	1	0.177	0.382	0	0	0	1
SOUTH	0.127	0.333	0	0	0	1	0.144	0.351	0	0	0	1	0.164	0.370	0	0	0	1
Lower Secondary	0.578	0.263	0.42	0.64	0.78	0.90	0.650	0.219	0.53	0.70	0.81	0.90	0.574	0.253	0.41	0.64	0.77	0.89
Secondary education	0.376	0.245	0.18	0.31	0.5	0.9	0.310	0.199	0.16	0.26	0.40	0.75	0.373	0.231	0.2	0.31	0.5	0.86
Graduates	0.044	0.074	0	0.02	0.06	0.15	0.072	0.086	0.02	0.05	0.08	0.2	0.053	0.076	0	0.03	0.07	0.18
TRADITIONAL	0.417	0.493	0	0	1	1	0.522	0.499	0	1	1	1	0.506	0.500	0	1	1	1
SCALE	0.276	0.447	0	0	1	1	0.181	0.385	0	0	0	1	0.174	0.379	0	0	0	1
SPECIALIZED	0.256	0.436	0	0	1	1	0.243	0.429	0	0	0	1	0.269	0.443	0	0	1	1
HIGH TECH	0.049	0.216	0	0	0	0	0.052	0.224	0	0	0	1	0.039	0.195	0	0	0	0
LIQUIDITY	1219.1	5713	57.32	233	759	4546	742.5	3366	31.51	128.8	423.6	2823	1830.7	9807	74.83	312.2	1045	5686
RFD	0.422	0.123	0.37	0.43	0.51	0.58	0.410	0.137	0.36	0.43	0.51	0.58	0.410	0.138	0.36	0.43	0.51	0.58
Δ LABOUR	0.030	0.142	0	0	0.05	0.20	0.035	0.793	0	0	0.05	0.20	0.018	0.334	-0.01	0	0.03	0.15
AGE	23.41	18.39	11	19	30	58	23.66	18.11	12	20	30	54	27.96	19.35	15	24	36	63

The table reports summary statistics (for each survey) for the variables included in the regression analysis.

Table 3: Percentage of innovative firms, by industry

Industry	**Obs**	**Product innovation(%)**	**Process innovation (%)**
Mining	3	0.0	33.3
Food	1336	24.7	40.2
Tobacco	6	16.6	33.3
Textiles	1175	35.2	34.6
Apparel	434	29.7	31.1
Leather	559	25.7	33.1
Lumber	391	25.3	43.7
Paper	386	23.8	46.1
Printing and publishing	404	22.7	43.8
Petroleum and coal products	61	18.0	37.7
Chemicals	659	38.2	37.3
Rubber and plastics	750	38.2	42.4
Nonmetallic and mineral products	825	27.0	38.1
Primary metal products	555	27.0	49.5
Fabricated metal products	1558	26.4	39.2
Machinery manufacturing	2017	44.2	38.1
Electronic computing equipment	61	57.4	39.3
Electrical machinery	504	39.3	38.3
Communication equipment	288	42.7	35.1
Medical equipment	263	43.	38.4
Motor vehicles	278	38.1	44.6
Other transportation	139	32.3	34.5
Furniture	795	38.1	30.3
Recycling related manufacturing	1	100.0	0.0
Others	5	20.0	20.0
Total	13463	33.1	38.5

The table reports the number of observations by industry and the percentage of firms that realized innovations by industry. Product innovation refers to firms that introduced product or product-related organizational innovations. Process innovation refers to firms that introduced process or process-related organizational innovations.

Table 4: RiskCalc Model

Factor	Weight
PROFITABILITY	11%
(Net Income + Taxes) / Assets	
LEVERAGE	26%
(Equity - Intangibles Assets) / Tangibles Assets	
DEBT COVERAGE	19%
(Ordinary Profit + Depreciation) / Interest Expenses	
GROWTH	6%
Sales Growth	
LIQUIDITY	13%
Current Assets / Current Liabilities	
Cash / Current Assets	
ACTIVITY	19%
Financial Charges / Sales	
Accounts Receivable Turnover	
SIZE	6%
Total Assets	

Our calculations on data available in Kocagil et al. (2002).

Table 5: Risk and Innovation

Variable	**Marg. Eff.**	**(Std. Err.)**
RISK	-1.283***	(0.462)
SIZE	0.082***	(0.011)
EXPORT	0.124***	(0.022)
CONSORTIUM	0.083***	(0.026)
CENTER	-0.015	(0.029)
SOUTH	-0.018	(0.043)
Secondary education	0.069	(0.043)
Graduates	0.486***	(0.143)
GROWTH	-0.027	(0.220)
SHARE	0.000	(0.001)
ISO9000	0.053***	(0.020)
International Competitors	-0.048	(0.035)
HHI	-0.120	(0.233)
RFD	0.249**	(0.104)
AGE	-0.002	(0.015)
ateco5_digit	0.137**	(0.053)
ateco4_digit	0.167***	(0.054)
ateco3_digit	0.151***	(0.052)
SCALE	0.028	(0.027)
SPECIALIZED	0.069***	(0.023)
HIGH TECH	0.167***	(0.046)

Number of observations	2646
$\chi^2_{(21)}$	257.217
Prob > χ^2	0.000
Pseudo R^2	0.075

The table reports regression marginal effects and associated standard errors (between parentheses). The dependent variable is INNOVATION, a dummy variable that take on a value of one if the firm innovated and zero otherwise. The regression is estimated by maximum likelihood probit model. $***$, $**$, $*$ indicate statistically significant at the 1%, 5%, and 10% level, respectively. The table also reports, as goodness-of-fit tests, the Pseudo R^2; as well as the χ^2 for a likelihood ratio test, and its p-value.

Table 6: First stage of 2SLS

Variable	**Coeff**	**(Std. Err.)**
Instrumental Variable		
Δ LABOUR	-0.015***	(0.003)
Control Variables		
SIZE	-0.001*	(0.000)
EXPORT	0.001	(0.001)
CONSORTIUM	0.001	(0.001)
CENTER	0.003**	(0.001)
SOUTH	0.003	(0.002)
Secondary education	-0.001	(0.002)
Graduates	0.007	(0.005)
GROWTH	-0.008	(0.009)
SHARE	0.000***	(0.000)
ISO9000	-0.003***	(0.001)
International Competitors	0.000	(0.001)
HHI	-0.023**	(0.010)
RFD	0.001	(0.004)
AGE	-0.003***	(0.001)
ateco5_digit	0.002	(0.002)
ateco4_digit	0.002	(0.002)
ateco3_digit	0.003	(0.002)
SCALE	-0.001	(0.001)
SPECIALIZED	-0.001	(0.001)
HIGH TECH	0.004*	(0.002)
Intercept	0.022***	(0.004)

Number of observations	2646
R^2	0.032
$F_{(21,2624)}$	5.252
Durbin (score) $\chi^2_{(1)}$	9.768
p (Durbin)	0.002

The table reports regression coefficients and associated standard errors (between parentheses). The dependent variable is RISK, the firm's one-year probability of default. The regression is estimated by OLS. $***$, $**$, $*$ indicate statistically significant at the 1%, 5%, and 10% level, respectively. The table reports, as goodness-of-fit tests, the R^2 and the F-statistic. The table also reports the Durbin score (and its p-value) as a test of exogeneity of RISK (in the 2SLS model).

Table 7: Model with instrumental variables

	2SLS		2SCML	
Variable	**Coeff**	**(Std. Err.)**	**Marg. eff.**	**(Std. Err.)**
RISK	-16.560***	(5.915)	-13.718***	(2.852)
SIZE	0.059***	(0.013)	0.053***	(0.016)
EXPORT	0.137***	(0.025)	0.107***	(0.024)
CONSORTIUM	0.094***	(0.032)	0.079***	(0.026)
CENTER	0.031	(0.037)	0.025	(0.028)
SOUTH	0.026	(0.051)	0.020	(0.040)
Secondary education	0.063	(0.048)	0.047	(0.041)
Graduates	0.493***	(0.154)	0.454***	(0.137)
GROWTH	-0.134	(0.251)	-0.106	(0.205)
SHARE	0.001	(0.000)	0.001*	(0.000)
ISO9000	0.001	(0.030)	-0.001	(0.025)
International Competitors	-0.043	(0.037)	-0.034	(0.033)
HHI	-0.466	(0.297)	-0.386*	(0.225)
RFD	0.258**	(0.119)	0.205**	(0.101)
AGE	-0.045*	(0.024)	-0.038**	(0.016)
ateco5_digit	0.154**	(0.067)	0.127**	(0.053)
ateco4_digit	0.184***	(0.069)	0.154***	(0.051)
ateco3_digit	0.197***	(0.069)	0.151***	(0.051)
SCALE	0.012	(0.032)	0.008	(0.026)
SPECIALIZED	0.052*	(0.027)	0.042*	(0.024)
HIGH TECH	0.215***	(0.069)	0.181***	(0.043)
Intercept	0.293*	(0.168)		
Number of observations	2646		2646	
$\chi^2_{(21)}$	185.73		556.68	
Prob > $\chi^2_{(21)}$	0.000		0.000	
Wald exog. $\chi^2_{(1)}$			9.46	
Prob > χ^2			0.002	

The table reports regression coefficients, marginal effects and associated standard errors (between parentheses). The dependent variable is a dummy that takes the value one if the firm introduced innovations, and zero otherwise. To control for endogeneity of RISK, regressions are estimated by two-stage least squares (2SLS) and by two-stage conditional maximum likelihood (2SCML). $***$, $**$, $*$ indicate statistically significant at the 1%, 5%, and 10% level, respectively. The table reports the χ^2 for a likelihood ratio test, and its p-value. For 2SCML estimation, the table reports Wald test (and its p-value) as a test of exogeneity of RISK.

Table 8: Product Innovation

	Probit		2SLS		2SCML	
Variable	**Marg. eff.**	**(Std. Err.)**	**Coeff**	**(Std. Err.)**	**Marg. eff.**	**(Std. Err.)**
RISK	-0.991*	(0.508)	-11.330**	(5.521)	-10.738***	(3.872)
SIZE	0.049***	(0.011)	0.038***	(0.012)	0.035**	(0.013)
EXPORT	0.189***	(0.021)	0.189***	(0.024)	0.175***	(0.027)
CONSORTIUM	0.039	(0.030)	0.049	(0.030)	0.046	(0.028)
CENTER	-0.007	(0.030)	0.021	(0.034)	0.022	(0.031)
SOUTH	-0.037	(0.045)	-0.005	(0.048)	-0.006	(0.045)
Secondary education	0.095**	(0.045)	0.085*	(0.045)	0.077*	(0.045)
Graduates	0.527***	(0.142)	0.539***	(0.144)	0.519***	(0.139)
GROWTH	-0.155	(0.230)	-0.223	(0.234)	-0.201	(0.219)
SHARE	0.001	(0.001)	0.001**	(0.000)	0.001**	(0.000)
ISO9000	0.013	(0.021)	-0.021	(0.028)	-0.021	(0.025)
International Competitors	0.032	(0.035)	0.032	(0.035)	0.029	(0.034)
HHI	-0.146	(0.250)	-0.358	(0.277)	-0.353	(0.249)
RFD	0.245**	(0.111)	0.238**	(0.111)	0.222**	(0.109)
AGE	-0.004	(0.015)	-0.035	(0.022)	-0.032*	(0.020)
ateco5_digit	0.093	(0.062)	0.104	(0.063)	0.097*	(0.060)
ateco4_digit	0.103*	(0.061)	0.115*	(0.062)	0.107*	(0.059)
ateco3_digit	0.078	(0.063)	0.102	(0.064)	0.095	(0.060)
SCALE	0.009	(0.029)	-0.002	(0.030)	-0.002	(0.029)
SPECIALIZED	0.120***	(0.024)	0.106***	(0.025)	0.095***	(0.029)
HIGH TECH	0.220***	(0.057)	0.248***	(0.064)	0.234***	(0.054)
Intercept			0.092	(0.157)		
Number of observations	2646		2646		2646	
$\chi^2_{(21)}$	294.16		263.63		341.00	
Prob > χ^2	0.000		0.000		0.000	
Durbin (score) $\chi^2_{(1)}$			2.390			
p (Durbin)			0.122			
Wald exog. $\chi^2_{(1)}$					4.30	
Prob > χ^2					0.038	

The table reports regression coefficients, marginal effects and associated standard errors (between parentheses). The dependent variable is a dummy that takes the value one if the firm introduced product or product-related organizational innovations, and zero otherwise. To control for endogeneity of RISK, regressions are also estimated by two-stage least squares (2SLS) and by two-stage conditional maximum likelihood (2SCML). $***$, $**$, $*$ indicate statistically significant at the 1%, 5%, and 10% level, respectively. The table reports the χ^2 for a likelihood ratio test, and its p-value.The table also reports the Durbin score (and its p-value) as a test of exogeneity of RISK (in the 2SLS model) and Wald test (and its p-value) as a test of exogeneity of RISK (in the 2SCML model).

Table 9: Process Innovation

Variable	Probit		2SLS		2SCML	
	Marg. eff.	**(Std. Err.)**	**Coeff**	**(Std. Err.)**	**Marg. eff.**	**(Std. Err.)**
RISK	-0.360	(0.410)	-5.230	(-4.470)	-5.033	(4.272)
SIZE	0.026***	(0.009)	0.022**	(0.010)	0.022**	(0.010)
EXPORT	-0.056***	(0.019)	-0.052***	(0.019)	-0.050**	(0.019)
CONSORTIUM	0.039*	(0.024)	0.045*	(0.025)	0.045*	(0.025)
CENTER	-0.003	(0.024)	0.010	(0.028)	0.010	(0.027)
SOUTH	0.018	(0.036)	0.031	(0.039)	0.032	(0.039)
Secondary education	-0.023	(0.035)	-0.022	(0.037)	-0.025	(0.036)
Graduates	-0.081	(0.117)	-0.046	(0.117)	-0.050	(0.121)
GROWTH	0.112	(0.182)	0.088	(0.190)	0.075	(0.187)
SHARE	-0.001	(0.001)	0.000	(0.000)	-0.000	(0.000)
ISO9000	0.038**	(0.017)	0.022	(0.023)	0.022	(0.023)
International Competitors	-0.079***	(0.024)	-0.075***	(0.029)	-0.078***	(0.025)
HHI	-0.008	(0.194)	-0.108	(0.225)	-0.115	(0.219)
RFD	0.016	(0.087)	0.020	(0.090)	0.021	(0.088)
AGE	0.003	(0.012)	-0.011	(0.018)	-0.011	(0.017)
ateco5_digit	0.051	(0.057)	0.050	(0.051)	0.057	(0.057)
ateco4_digit	0.069	(0.057)	0.069	(0.050)	0.075	(0.055)
ateco3_digit	0.086	(0.060)	0.086*	(0.052)	0.096	(0.061)
SCALE	0.017	(0.023)	0.014	(0.024)	0.012	(0.023)
SPECIALIZED	-0.051***	(0.019)	-0.054***	(0.021)	-0.054***	(0.019)
HIGH TECH	-0.050	(0.042)	-0.033	(0.052)	-0.030	(0.050)
Intercept			0.201	(0.127)		
Number of observations	2646		2646		2646	
$\chi^2_{(21)}$	64.319		60.74		74.24	
Prob $> \chi^2$	0.000		0.000		0.000	
Durbin (score) $\chi^2_{(1)}$			1.268			
p (Durbin)			0.260			
Wald exog. $\chi^2_{(1)}$					1.19	
Prob $> \chi^2$					0.275	

The table reports regression coefficients, marginal effects and associated standard errors (between parentheses). The dependent variable is a dummy that takes the value one if the firm introduced process or process-related organizational innovations, and zero otherwise. To control for endogeneity of RISK, regressions are also estimated by two-stage least squares (2SLS) and by two-stage conditional maximum likelihood (2SCML). $***$, $**$, $*$ indicate statistically significant at the 1%, 5%, and 10% level, respectively. The table reports the χ^2 for a likelihood ratio test, and its p-value. The table also reports the Durbin score (and its p-value) as a test of exogeneity of RISK (in the 2SLS model) and Wald test (and its p-value) as a test of exogeneity of RISK (in the 2SCML model).

Table 10: Split for dimension

	Small		Big	
Variable	**Marg. eff.**	**(Std. Err.)**	**Marg.eff.**	**(Std. Err.)**
RISK	-16.992***	(2.287)	-7.723	(4.798)
SIZE	0.012	(0.042)	0.045**	(0.019)
EXPORT	0.093***	(0.032)	0.128***	(0.034)
CONSORTIUM	0.064*	(0.035)	0.095***	(0.032)
CENTER	0.015	(0.037)	0.044	(0.038)
SOUTH	-0.014	(0.054)	0.029	(0.061)
Secondary education	-0.048	(0.056)	0.097*	(0.056)
Graduates	0.174	(0.223)	0.479**	(0.191)
GROWTH	-0.575**	(0.277)	0.316	(0.286)
SHARE	0.001	(0.001)	0.001	(0.001)
ISO9000	-0.002	(0.028)	0.022	(0.037)
International Competitors	-0.049	(0.053)	-0.059	(0.042)
HHI	-0.289	(0.294)	-0.472	(0.320)
RFD	0.138	(0.144)	0.273**	(0.131)
AGE	-0.063***	(0.021)	-0.009	(0.021)
ateco5_digit	0.115	(0.099)	0.119**	(0.055)
ateco4_digit	0.125	(0.101)	0.150***	(0.056)
SCALE	0.056	(0.036)	-0.044	(0.040)
SPECIALIZED	0.027	(0.032)	0.066**	(0.031)
HIGH TECH	0.240***	(0.060)	0.126**	(0.060)
Number of observations	1326		1300	
$\chi^2_{(21)}$	440.12		127.59	
Prob > χ^2	0.000		0.000	
Wald exog. $\chi^2_{(1)}$	6.43		1.72	
Prob > χ^2	0.011		0.190	

The table reports marginal effects and associated standard errors (between parentheses). The dependent variable is a dummy that takes the value one if the firm introduced innovations, and zero otherwise. To control for endogeneity of RISK, regressions are estimated by two-stage conditional maximum likelihood (2SCML). $***$, $**$, $*$ indicate statistically significant at the 1%, 5%, and 10% level, respectively. The table reports the χ^2 for a likelihood ratio test, and its p-value. The table also reports Wald test (and its p-value) as a test of exogeneity of RISK.

Table 11: Zscore with time effects

	2SLS		2SCML	
Variable	**Coeff**	**(Std. Err.)**	**Marg.eff.**	**(Std. Err.)**
Zscore	1.194**	(0.534)	1.430**	(1.867)
survey2000	-0.031	(0.077)	-0.008	(0.266)
survey2003	-0.034	(0.054)	-0.023	(0.185)
SIZE	0.187***	(0.057)	0.220***	(0.200)
EXPORT	0.095***	(0.036)	0.093**	(0.124)
CONSORTIUM	0.124**	(0.055)	0.128**	(0.190)
CENTER	-0.045	(0.049)	-0.053	(0.167)
SOUTH	0.220*	(0.125)	0.220*	(0.436)
Secondary education	-0.048	(0.070)	-0.058	(0.240)
Graduates	0.525**	(0.245)	0.606**	(0.847)
GROWTH	0.422	(0.362)	0.462	(1.247)
SHARE	0.001	(0.001)	0.001	(0.002)
ISO9000	0.108***	(0.040)	0.119**	(0.139)
International Competitors	-0.018	(0.044)	-0.011	(0.151)
HHI	0.933	(0.613)	1.134	(2.129)
RFD	-0.247	(0.223)	-0.311	(0.771)
AGE	0.076*	(0.045)	0.092*	(0.156)
ateco5_digit	-0.037	(0.153)	-0.061	(0.527)
ateco4_digit	0.072	(0.138)	0.065	(0.472)
ateco3_digit	-0.053	(0.157)	-0.085	(0.539)
SCALE	0.004	(0.042)	0.005	(0.143)
SPECIALIZED	0.021	(0.042)	0.017	(0.143)
HIGH TECH	0.069	(0.077)	0.081	(0.266)
Intercept	-2.992**	(1.476)		
Number of observations	6668		6668	
$\chi^2_{(21)}$	84.28		69.74	
Prob > χ^2	0.000		0.000	
Durbin (score) $\chi^2_{(1)}$	38.28			
p (Durbin)	0.000			
Wald exog. $\chi^2_{(1)}$			38.99	
Prob > χ^2			0.000	

The table reports regression coefficients, marginal effects and associated standard errors (between parentheses). The dependent variable is a dummy that takes the value one if the firm introduced innovations, and zero otherwise. To control for endogeneity of Zscore, regressions are estimated by two-stage least squares (2SLS) and by two-stage conditional maximum likelihood (2SCML). $***$, $**$, $*$ indicate statistically significant at the 1%, 5%, and 10% level, respectively. The table reports the χ^2 for a likelihood ratio test, and its p-value. The table also reports the Durbin score (and its p-value) as a test of exogeneity of Zscore (in the 2SLS model) and Wald test (and its p-value) as a test of exogeneity of Zscore (in the 2SCML model).

Table 12: Zscore panel

	Probit		2SLS		2SCML	
Variable	**Marg.eff.**	**(Std. Err.)**	**Coeff**	**(Std. Err.)**	**Marg.eff.**	**(Std. Err.)**
Zscore	-0.002	(0.071)	0.341*	(0.198)	0.329**	(0.139)
SIZE	0.095***	(0.055)	0.106***	(0.024)	0.109***	(0.015)
EXPORT	0.086**	(0.101)	0.056	(0.041)	0.041	(0.038)
CONSORTIUM	0.110***	(0.135)	0.131***	(0.045)	0.125***	(0.033)
CENTER	-0.060	(0.145)	-0.072	(0.055)	-0.072*	(0.045)
SOUTH	-0.046	(0.233)	0.000	(0.087)	-0.018	(0.070)
Secondary education	-0.024	(0.189)	-0.054	(0.063)	-0.015	(0.056)
Graduates	0.495*	(0.863)	0.603**	(0.306)	0.674***	(0.258)
GROWTH	-0.007	(0.989)	-0.020	(0.352)	-0.069	(0.290)
SHARE	-0.000	(0.002)	0.000	(0.001)	0.000	(0.001)
ISO9000	0.000	(0.082)	0.002	(0.029)	0.017	(0.025)
International Competitors	0.084**	(0.128)	0.007	(0.051)	0.021	(0.050)
HHI	0.084	(1.067)	0.324	(0.416)	0.315	(0.326)
RFD	0.039	(0.625)	-0.124	(0.249)	-0.144	(0.198)
AGE	-0.056**	(0.070)	-0.014	(0.033)	-0.010	(0.028)
ateco4_digit	-0.003	(0.112)	0.018	(0.042)	0.020	(0.033)
ateco3_digit	-0.026	(0.122)	0.008	(0.046)	0.005	(0.037)
SCALE	0.028	(0.122)	0.006	(0.045)	0.006	(0.037)
SPECIALIZED	0.088**	(0.112)	0.082**	(0.039)	0.076**	(0.031)
HIGH TECH	-0.001	(0.238)	0.004	(0.084)	-0.004	(0.069)
Intercept			-0.435	(0.544)		
Number of observations	1220		1220		1220	
$\chi^2_{(21)}$	80.85		72.50		178.53	
Prob > χ^2	0.000		0.000		0.000	
Wald exog. $\chi^2_{(1)}$					4.20	
Prob > χ^2					0.040	

The table reports regression coefficients, marginal effects and associated standard errors (between parentheses). The dependent variable is a dummy that takes the value one if the firm introduced innovations, and zero otherwise. To control for endogeneity of Zscore, regressions are also estimated by two-stage least squares (2SLS) and by two-stage conditional maximum likelihood (2SCML). ∗∗∗, ∗∗, ∗ indicate statistically significant at the 1%, 5%, and 10% level, respectively. The table reports the χ^2 for a likelihood ratio test, and its p-value. The table also reports Wald test (and its p-value) as a test of exogeneity of Zscore (in the 2SCML model).