

CERBE Working Paper Series

**RELATIONSHIP LENDING AND INNOVATION:
EMPIRICAL EVIDENCE
ON A SAMPLE OF EUROPEAN FIRMS**

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Working Paper No. 4
March 2015

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Relationship lending and innovation: Empirical evidence on a sample of European firms

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Abstract

This paper investigates the impact of relationship lending on innovation (the probability to innovate and the intensity of innovation). Using a unique dataset providing detailed information on bank-firm relationships across European firms, we relate different proxies of relationship lending (soft information, long-lasting relationships, number of banks, share of the main bank) to innovation. We find a very strong and robust positive effect of ‘soft-information intensive’ relationships, a less robust positive effect of long-lasting relationships and a negative effect of credit concentration as measured by the number of banking relationships. We also find that ‘soft-information intensive’ relationships reduce credit rationing for innovative firms, while long-lasting relationships seem to favour innovation via other relational channels. These results raise some concern on the impact of screening processes based on automatic procedures, as those suggested by the Basel rules, on firms’ capability to finance innovative activities in Europe.

Keywords: relationship lending; innovation; R&D; credit constraints; soft information

JEL Classification: G10; G21; G30; O30; O31

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We wish to thank the participants to the Second Meeting of the CERBE (Roma, December 15 2014) for helpful comments. All remaining errors are ours.

1. Introduction

Innovative activity and the creation of new knowledge are the main engine for economic growth. According to Schumpeter the banker plays a crucial role in helping to get innovations financed: he is the ‘ephor of the exchange economy’ (Schumpeter 1912), literally the ‘one who oversees’, like the magistrates who had supervisory power over the Spartan kings. However evaluating innovative ideas is not an easy task to the bank since information asymmetries are particularly severe, and innovative firms often turn out to be financially constrained, especially when internal financial resources are limited (small and young firms). All innovative firms invest in high-risk-high-return projects that are ‘new’ by definition so that low cost ‘hard information’ (credit history, balance sheet data, rating, scoring) is not sufficient to assess their creditworthiness. Innovative projects’ evaluation needs the production of costly ‘soft information’ in that banks must interview innovative firms’ managers, who often prefer to protect their secrecy, in order to evaluate their future plans. Moreover, innovative firms are characterised by a high share of intangible assets that cannot be pledged as collateral and the investments in physical capital are often firm-specific and have little collateral value (Hall 2010).

During the last decades, in order to meet Basel II capital requirements, many banks have been adopting new screening technologies based on standardised internal rating models that use ‘hard information’. These methods progressively substituted pre-existing technologies based also on ‘soft information’ (judgement, opinions, notes...), the so-called ‘relationship lending’ technologies, that left loan officers with a certain degree of discretionality. Are banks that adopt ‘transaction lending’ technologies, based essentially on the use of ‘hard information’, still able to perform the crucial Schumpeterian role of ‘ephor’ of capitalism?

In this paper we investigate the impact of relationship lending on innovation. In particular our analysis aims at sorting out whether and to what extent a banker able to gather relevant soft information about the prospects and the creditworthiness of a firm may stimulate the firm’s innovation activity.

Empirical evidence emerging from the ‘Community Innovation Survey’ carried out by European national statistical offices on firms in EU countries shows that the main obstacles inhibiting innovation in the majority of European firms are financial factors. Furthermore, several empirical studies using these data demonstrate that the lack of appropriate sources of finance is actually one of the main obstacles for both the probability and the intensity of innovation throughout Europe (Mohnen and Roller 2005; Savignac 2006; Canepa and Stoneman 2008; Mohnen et al. 2008).

Although venture capital may be viewed as the most suitable form of external finance for the start-up and expansion of high-tech small firms, bank loans remain the most important source of

external finance for innovative firms in Europe (Giudici and Paleari 2000; Colombo and Grilli 2007). Innovation activity may therefore depend on the amount of bank credit available to the firm. Whenever the amount of soft information produced about innovative firms reduces information asymmetries and financial constraints, strong bank-firm relationships may foster innovation.

However, according to Alessandrini, Presbitero and Zazzaro (2010) the bank's role is not limited to provide innovative firms with access to financial resources but it consists in a wider relation-based support to the innovative vein of the entrepreneur and his new production strategy. Therefore should strong bank-firm relationships have a positive impact on the probability of innovation, this might be due to the lower financial constraints faced by the borrower (financial channel) or be the consequence of the greater ability of relationship banks relative to transaction banks to encourage borrowers to innovate and grow (relational channels).

Based on an unique dataset of manufacturing firms across European countries (the EFIGE Bruegel-Unicredit dataset) we examine the role of relationship lending in explaining firm's innovation, both the probability to innovate (extensive margin) and the intensity of innovation (intensive margin). We find a very strong and robust positive effect of 'soft-information intensive' relationships, a less robust positive effect of long-lasting relationships and a negative effect of credit concentration as measured by the number of banking relationships. Moreover, in order to disentangle the channels whereby strong bank-firm relationships may affect firms' innovation activity, we test whether relationship lending reduces credit constraints for innovative firms. We find evidence of a financial channel for soft-information intensive relationships, while long-lasting relationships seem to favour innovation via other relational channels.

This study contributes to the existing literature in several directions. Firstly, while most of the literature mainly focuses on indirect proxies for relationship lending, such as the length of the relationship and credit concentration, we use a unique dataset that accounts for a direct measure of the type of information the bank asks in order to assess the borrower's creditworthiness. We argue that the traditional indicators have some important drawbacks, since they are based on the assumption that, whenever there are conditions making the production of soft information more likely, this information is actually used to evaluate borrowers. Indeed, there may be situations where soft information is produced but it is not used to assess the creditworthiness of borrowers.

Secondly, by testing whether relationship lending reduces credit constraints for innovative firms, this study deepens the analysis of the channels whereby relationship lending affects firms' innovation activity. Finally, while most of the empirical studies use national data, we investigate the impact of bank-firm relationships on innovation in the area of continental Europe (Germany, France, Italy and Spain). This area is characterised by a bank-based financial system that has been

becoming more and more integrated over the last 20 years: financial market deregulation has been shaped both by the abolition of capital account restrictions and the adoption of common legislative standards.

The remainder of the paper is organised as follows. Section 2 reviews the related theoretical and empirical literature mainly focussing on microeconomic analyses. Section 3 describes the dataset and reports descriptive statistics. Section 4 illustrates the econometric methodology. Section 5 presents and comments the empirical results, that we subject to some robustness tests in Section 6. The last Section concludes the paper.

2. Review of the literature

The financing of innovation plays a critical role in promoting economic growth but, due to the nature of the investment (innovation activities are riskier and harder to be collateralised), innovative firms often turn out to be financially constrained.

The literature on the financing of innovation, mainly R&D investments financing, suggests that internal finance is the primary financial source for innovative firms, because external finance may be very difficult or costly for them due to asymmetric information problems¹. The argument goes as follows: the innovative firm has better information about the probability of success and the nature of the innovative project than potential investors, so that external finance can be more expensive because it is harder for investors to distinguish good from bad projects (i.e. the ‘lemons premium’ for innovation will be higher); moreover, revealing information could represent a relevant cost to innovative firms because of the ease of imitation, and this reduces the quality of their signal to the market (Bhattacharya and Ritter 1983). The asymmetric information problem may result in financial constraints especially for those innovative firms whose internal financial resources are limited, i.e. small and young firms. Consistently with the theoretical prediction that retained earnings play an important role for firms that innovate, the empirical literature finds a positive correlation between R&D investments and cash-flow (Hall 1992; Himmelberg and Petersen 1994; Mulkey, Hall and Mairesse 2001; Bond, Harhoff and Van Reenen 2005; Ughetto 2008).

When firms need external finance, while the conventional prediction of the pecking order theory (Myers and Majluf 1984) is that debt financing is preferred to external equity, in the case of innovative firms two different approaches suggest an inverted pecking order. More innovative firms are likely to rely less on debt finance in order to minimise bankruptcy costs that are higher for innovative firms because they have a higher proportion of intangible assets (bankruptcy costs approach) or because they are more likely to be willing to allocate control rights to outside investors

¹For a review of the theoretical and empirical literature on the financing of innovation, see Hall (2010).

(i.e. to issue new equity) since they have more attractive investment opportunities and fewer tangible assets (control rights approach). Consistently with the latter approaches, empirical studies on the financial structure of innovative firms suggest that innovative firms are more likely to issue new equity (Friend and Lang 1988; Hall 1992; Atanassov, Nanda and Seru 2007; Czarnitzki and Kraft 2009). However, this proves to be the case for large innovative firms². Since many innovative firms are small, they may have more difficulties to issue outside equity: when external funds are needed, their most frequent choice may be bank loans, although debt is not the most suitable source for financing innovation (Berger and Udell 1998). Basically the uncertain nature of innovation makes banks less suitable financiers because the knowledge asset created by innovation investments is intangible, firm-specific and mainly embedded in human capital (Hall 2010), because innovative firms tend to generate, at least initially, limited and unstable cash-flow (Brown, Martinsson and Petersen 2012), because banks may have limited skills to assess technologies at the early stages of adoption (Rajan and Zingales 2003, Ueda 2004; Atanassov, Nanda and Seru 2007).

A way to overcome the disadvantage of bank loans in the financing of innovation may be relationship lending, in which the lending bank invests in collecting information on the quality of the borrower, and this investment is especially valuable when the information about a firm and potential investment opportunities are most uncertain. Therefore lending relationships may play a crucial role in the financing of small innovative firms (Boot 2000; Berger and Udell 2006).

Relationship lending, as opposed to transaction lending, is characterised by three conditions (Boot 2000): i) the intermediary collects information beyond readily available public information; ii) information gathering takes place over time through multiple interactions with the borrower, often through provision of multiple financial services; iii) the information remains confidential (proprietary). The literature on relationship lending has measured the strength of bank-firm relationships along several definitions, all focused on the basic dimension of private information. Two kinds of private information flow inside a firm-bank relationship: hard information (credit history, balance sheet data, rating, scoring) and soft information (judgement, opinions, notes...). Soft information is collected by the interaction between loan officer and the firm's manager, and it appears to be very important particularly for small firms because they usually are not able to provide reliable hard information to their bank (Berger, Klapper and Udell 2001). By building a stronger bank-firm relationship the firm can enhance the flow of information to the bank (Petersen and Rajan 1994; Berger and Udell 1995; Harhoff and Körting 1998), while the existence of multiple banking relationships reduces the privacy and value of the information, because it is spread over each bank that screens and/or monitors the firm (Cole 1998; Carletti 2004). Moreover, if banks have

² See also Blass and Yosha (2003) and Aghion et al. (2004).

the same information about the quality of the firm, firms may change lenders more easily, reducing the expected duration of the relationship and the incentive for the bank to invest in the acquisition of private information (Bhattacharya and Thakor 1993)³.

However Boot (2000) suggests that relationship lending has a bright and a dark side. On the one hand, relationship lending reduces the extent to which moral hazard and adverse selection affect credit availability to borrowers, on the other hand, the relationship bank may be able to build an informational monopoly that it can exploit by charging higher loan interest rates (Sharpe 1990) or by threatening not to extend further credit (Rajan 1992). The potential informational capture by the bank may induce the firm to increase the number of banking relationships. Multiple banking relationships may also be a way for firms to assure themselves against liquidity shocks of the main bank (Detragiache, Garella and Guiso 2000) or a way to reduce the risk of credit rationing when banks prefer to finance more firms providing them only a limited share of their demand for credit⁴. The overall effect of strong relationships is a trade-off in costs and benefits between lenders and borrowers through interactions across time, space and financial products.

Empirical evidence generally suggests that strong lending relationships enhance firms' ability of obtaining external funds through a quantity channel and a price channel (Petersen and Rajan 1994; Berger and Udell 1995; Cole 1998; Elsas and Krahnert 1998; Harhoff and Körting 1998). In order to measure relationship lending the empirical literature has focused mostly on three dimensions: time, distance and exclusivity⁵.

Time represents a relationship dimension characterised by repeated interactions between the borrower and the lender, whereby the lender learns and collects public and private information about the borrower. Public information about a firm is proxied by the age of the borrower, while the duration of the relationship is a proxy for the production of private information: it is supposed to capture the private information that the lender acquires as part of its relationship with the firm (Petersen 1999; Ongena and Smith 2001).

Distance is a relationship dimension that affects the type and usage of information produced by banks. Contact between lender and borrower is facilitated by geographical and also organisational proximity. Banks' organisational structure and the separation from decision-making influence the

³See also von Rheinbaben and Ruckes (2004) that find a negative relation between the number of banking relationships and the flow of private information to the bank.

⁴If the bank has limited loanable funds, by partially financing all loan applicants, it may get better diversification of risk (Harhoff and Körting 1998) or increase the number of customer relationships in order to maximise cross-selling revenues (Cosci, Meliciani and Sabato 2009). Moreover a large bank may find it difficult and costly to process locally-based and often qualitative information about a loan applicant (Berger, Klapper and Udell 2001), so that it may grant a loan only if another, supposedly more informed, bank already finances the borrower.

⁵Another relationship dimension is cross-product synergies, that represent the scope of the financial services provided by the bank. It captures the idea that lenders learn more about a borrower if they do more than just lend to the borrower (Petersen 1999). See also Cole (1998); Boot (2000).

strength of the relationships (Stein 2002). Soft information deteriorates in the transmission within the bank organisation as the functional distance between hierarchical levels increases (Alessandrini, Presbitero and Zazzaro 2010).

Exclusivity is a relationship dimension that measures the extent to which a firm concentrates its borrowing on a single lender, i.e. the degree of a firm's dependence on its potential lender as a source of financial services (Cole 1998). Information may be more complete, more accurate and easier to interpret the more exclusive a bank relationship is. The private information produced by a potential lender about a firm with multiple relationships is less valuable to that potential lender because of free-rider problem and also because the number of relationships may proxy for firm credit quality, i.e. 'lower quality firms are forced to shop around in order to find a lender that will extend credit' (Cole 1998, pp. 963-964). The measures generally used by empirical literature as proxies for exclusive relationships are the number of banking relationships and the share of debt held at the main bank.

A recent strand of literature has focused on the impact of relationship lending (measured along different dimensions) on firm's innovation activity. Herrera and Minetti (2007) focus on the time dimension and find that longer relationships positively affect innovation with a higher effect on product innovation than on process innovation. They also find that the length of the credit relationship fosters the introduction and acquisition of new technologies rather than internal research. Giannetti (2012) focuses on the time dimension and the exclusivity dimension (number of banking relationships and share of the main bank) and find that longer relationships and a higher share of the main bank have a positive impact on the capacity of high-tech small firms to innovate, in both the 'discovery phase' (extensive margin) and the 'introduction phase' (intensive margin), while this is not the case for all small firms. Micucci and Rossi (2013) focus on the time dimension and the exclusivity dimension (credit concentration measured by the Herfindahl concentration index of bank debt among all lending banks) and find that longer relationships positively affect both the propensity and the intensity of R&D activities, while credit concentration has a negative effect on the probability to carry out R&D (it has no significant effect on the intensity). Frazzoni et al. (2014) focus on the exclusivity dimension by using the ratio of firm's debt with its main bank to firm's total assets (a measure of bank debt concentration) as a proxy for relationship lending and find that it significantly affects the probability that the firm introduces product innovation. Alessandrini, Presbitero and Zazzaro (2010) focus on the (organisational) distance dimension and find that firms located in provinces where the local banking system is functionally distant (with a higher distance between bank branches and headquarters) are less inclined to introduce process and product

innovations. Furthermore, in such provinces credit rationing is more likely to occur and innovative firms tend to be penalised.

Differently from previous papers⁶, we extend the analysis of the impact of bank-firm relationships on innovation to a sample of European bank-based systems. Moreover, in addition to the traditional and most conventional proxies for relationship lending along the time and the exclusivity dimensions, we rely on direct data on the type of information the bank uses in order to assess the firm's creditworthiness.

3. Data and descriptive statistics

3.1. The sample

The data source is the EFIGE Bruegel-Unicredit dataset. This is based on questionnaire data for representative samples of manufacturing firms (with a lower threshold of 10 employees) across European countries. As the survey has been run in early 2010, information is mostly collected as a cross-section for the last available budget (year 2008), although some questions cover the period 2007-2009 and/or the behaviour of firms during the crisis. The sample covers five large countries (Germany, France, Italy, Spain and the UK) with a target sample of firms initially set at around 3,000 firms and two smaller countries (Austria and Hungary) with a target sample of about 500 firms. Questionnaire data are integrated with balance sheet data. Since the aim of the paper is to assess the impact of bank-firm relationships on innovation, and relationship lending is thought to be predominant in bank-based systems, we focus on the four largest bank-based European countries (France, Germany, Italy and Spain).

In order to measure innovation, the empirical research has often identified innovative firms either as undertaking some R&D activity or as belonging to high-tech industries. As in Giannetti (2012) we consider as innovative firms those firms that report to have carried out any product or process innovation. Compared with the identification based on R&D investments, this has the advantage of identifying innovative firms referring to an output rather than an input indicator (Magri 2009). Also it captures radical or incremental changes to firms' products and processes that may occur even in the absence of formalised R&D activities and this is especially true within small firms⁷.

In particular we construct the dummy variable 'innovation' that takes the value of one if the firm answers "yes" to the question: 'In the last three years (2007-2009) has the firm carried out any product or process innovation?'. We complement the information on the choice to innovate with the

⁶All the above studies that we reviewed are on Italian data.

⁷The question on innovation requires it to be new to the firm not necessarily to the market, implying that data capture both original innovations and imitation and adoption by the firm.

intensity of innovation measured as the percentage of turnover from innovative products sales on average in the period 2007-2009. However, in order to check the robustness of our results, in Section 6 we also consider an indicator based on R&D activities. To this end we construct the dummy variable ‘R&D’ that takes the value of one if the firm answers ‘yes’ to the question: ‘In the last three years (2007-2009) has the firm undertaken any R&D activities?’ and we measure the intensity of R&D activities as the percentage of total turnover invested in R&D on average in the period 2007-2009.

Moreover, in order to test whether relationship lending reduces credit constraints for innovative firms or its effect on firm’s innovation activity goes through other relational channels, we construct the dummy variable ‘more credit’ that takes the value of one if the firm answers ‘yes’ to the question: ‘During the last year, was the firm willing to increase its borrowing at the same interest rate of its current credit line?’ and the dummy variable ‘rationed’ that takes the value of one if the firm willing more credit (i.e. more credit=1) answers ‘yes, applied for it but was not successful’ to the question: ‘During the last year, did the firm apply for more credit?’.

Table 1 reports the frequencies, intensities and financing sources of innovation and R&D in our sample countries (France, Germany, Italy, Spain)⁸.

The percentage of firms innovating ranges from 56% in France to 70% in Spain, with the lowest intensity in France (9%) and the highest one in Italy (14%). Looking at the sources of investment financing by innovative firms, self-financing appears the main source (with percentages ranging from 39% to 56%), but the importance of bank credit is also sizeable (everywhere above 20% with the peaks of 30% in France and 32% in Spain). Leasing and factoring are also important investment financing sources for innovative firms with percentages around 10% in France and Germany and even higher in Italy (23%) and Spain (19%). Finally, the data on credit rationing, not reported in the table, indicate that on average a higher percentage of innovative firms are willing more credit (41% of positive answers for innovative firms versus 34% of positive answers for non-innovative firms), but there is no substantial difference in credit rationing (25% of the innovative firms that demand more credit versus 27% of the non-innovative firms that demand more credit).

In all countries the percentage of firms undertaking R&D investments (everywhere around 50%) is lower than that of innovative firms, showing that a share of innovative firms is not engaged in formal R&D activity. The largest difference is observed in Spain where 70% of the firms declare to be innovative but less than 50% declare to invest in R&D. The R&D intensity is similar across countries (between 3% and 4% of firms’ turnover). Looking at R&D financing, again self-financing

⁸The financing sources of innovation are the financing sources of investments in plants, machines, equipment and ICT of innovative firms, while the financing sources of R&D are those of R&D activities.

appears the main source in all countries (on average over 70% of R&D activities are financed by internal funds except in Spain where the percentage is nearly 60%). Bank credit represents the second more important source with percentages everywhere above 10% with a peak of nearly 19% in Spain. All the other sources appear far less important. It is worth noticing, however, the non-negligible role of leasing and factoring for Spain and Italy (9% and 7% respectively).

3.2. Bank-firm relationships variables

The EFIGE questionnaire gathers relevant information on bank-firm relationships from which it is possible to construct indicators of relationship lending that improve, and add to, the traditional measures commonly used in empirical studies.

We argue that two complementary features of relationship lending are important: the multiple interactions over time of a loan officer with the same borrower that are supposed to ‘produce’ soft information (a loan officer cannot avoid to ‘obtain’ soft information about a borrower, i.e. he cannot avoid to get a personal opinion of a loan applicant) and the ‘use’ of this soft information to evaluate the borrower’s creditworthiness.

The time dimension, as measured by the duration of the relationship, and the exclusivity dimension, as measured by (the inverse of) the number of banking relationships and the share of the main bank, capture the first feature of relationship lending stated above: duration is supposed to reflect the amount of soft information produced over time and the smaller the number of banking relationships and the larger the share of firm’s debt held at the main bank, the closer is the bank-firm relationship and the more likely a relationship lending technology is to be adopted.

We are not aware of any empirical study using a proxy for relationship lending that takes into account also the second complementary and important feature of relationship lending, i.e. the ‘use’ of soft information to evaluate the borrower’s creditworthiness. Indeed there may be situations where soft information is produced but it is not used to assess the borrower’s creditworthiness. This is particularly true with Basel II regulation: a firm may keep on borrowing from the same bank over time (it may be the less distant one or the one that produces efficient services) also when the bank evaluates its creditworthiness only on the basis of hard information. The EFIGE dataset allows us to construct an indicator of bank-firm relationships that measures the second feature of relationship lending. It is based on the answers to the question: ‘Which type of information does the bank normally use/ask to assess your firm’s creditworthiness?’ (question F16). We have classified the answer options as hard and soft information according to table 2.

Hard information is quantitative as it consists mainly of numbers and it is also rather ‘backward looking’ (e.g. balance sheet data), on the opposite, soft information is qualitative as it consists

mainly in words expressing subjective judgement, opinions and perception and it is rather ‘forward looking’ (e.g. business plan). Based on this classification we construct the dummy variable ‘soft’ that takes the value of one whenever the bank uses ‘interviews with management on firm’s policy and prospects’ and/or ‘business plan and firm’s target’ in order to evaluate the firm’s creditworthiness. We add the soft-information indicator to the traditional time and exclusivity dimensions.

We measure the time dimension by the ‘perceived’ duration of the relationships. More than the ‘actual duration’ measured by the length in years of the relationship, what matters is the reason why the firm chooses the main bank. The use of the ‘actual duration’ of the bank-firm relationship as a proxy for its strength may be criticised for two main reasons. First of all, when the duration is measured continuously by the number of years, it is assumed that a relationship of 10 years is very different from a relationship of 5 years, while it is likely that a relationship is ‘perceived’ as long-lasting by a firm and by a bank when it is longer than a given number of years⁹; secondly, a firm may borrow from the same bank for a long period for reasons that are different from those characterising relationship lending. This is clear when we look at the answers in the EFIGE questionnaire to the question: ‘Which factors are key in the choice of a main bank?’ (question F12). A firm may choose the main bank because it offers competitive services and funding or efficient internet services, because it is conveniently located or it has an extensive international network, or it is the Group’s main bank. In all these cases the reasons of the actual duration of a bank-firm relationship are very different from those implicit in the conditions characterising relationship lending as in Boot (2000). Other key factors in the choice of the main bank, that may be considered more related with relationship lending, are that the bank’s lending criteria are clear and transparent or the bank has flexible procedures/not constrained by red tape or, finally, that the bank has a long-lasting relationship with the firm. Based on these answers, we construct the dummy variable ‘long-lasting relationships’ that takes the value of one when the firm answers that the key factor in its choice of the main bank is the bank having a long-lasting relationships with the firm¹⁰. This indicator is meant to measure the closeness of the relationship as ‘perceived’ by the firm that chooses a main bank because it is an important part of its network, a network of relationships built over time. Finally, we measure the exclusivity dimension by the number of banking relationships and the share of debt held at the main bank.

⁹Cole (1998) finds that lenders are more likely to extend credit if they have a pre-existing relationship with the borrower, but with no incremental effect of longer duration than one year.

¹⁰Details on the questions from the survey used to construct the indicators of soft information and long-lasting relationships are reported in the Appendix.

Table 3 reports summary statistics on the indicators of bank-firm relationships for all countries distinguishing between innovative and non-innovative firms and between R&D and non-R&D firms.

Innovative firms have less exclusive relationships (they have a significantly higher number of banking relationships and a significantly lower share of the main bank) than non-innovative firms, while the percentage of firms choosing the main bank because it has long-lasting relationships with the firm is not significantly different between innovative and non-innovative firms. Finally, the use of soft information is much more widespread among innovative firms (65% of positive answers for innovative firms versus 58% of positive answers for non-innovative firms). Looking at the differences between R&D and non-R&D firms, table 3 shows the same patterns, with a larger (significant) difference in the use of soft information (69% of positive answers for firms investing in R&D versus 55% for firms not investing in R&D).

3.3. Other financial and control variables

The econometric analysis will allow testing whether the differences in bank-firm relationships emerging from the descriptive statistics affect firms' innovative behavior when controlling for other factors possibly affecting innovation¹¹. Among these factors, we distinguish between financial variables and other control factors. Financial factors include external financing, captured by long- and short-term leverage, and internal financing, captured by cash-flow. Moreover, for a restricted sample of firms for which we have information (all firms answering the question: 'What kind of financial instruments have been used to satisfy your firm's financing needs?'), we include a dummy variable for each possible answer/financial instrument (Equity, Venture capital and private equity, Short-term bank credit, Medium- or long-term bank credit, Securities, Public funds, Tax incentives, Leasing or factoring).

Financing conditions for both internal and external sources may depend on firm's characteristics so that we control for:

- Size (proxied by the number of employees): larger firms benefit more from innovation due to economies of scale. Furthermore they have more overall physical assets that could serve as collateral compared to smaller firms and may be more transparent, as their activities and output are more easily verifiable to banks (Petersen and Rajan 1994; Berger and Udell 1998).
- Age (measured by the number of years since the establishment of the firm): older firms tend to be more informationally transparent than younger firms due to their richer track record (age may be considered a proxy for public information). Furthermore they can use earlier profit

¹¹ All the variables used in this study are defined in the Appendix (table A).

accumulations for financing innovation and can innovate by building on their previous inventions (while younger firms may need to undertake more fundamental R&D which requires more resources and is much more uncertain).

- Group membership (proxied by a dummy variable equal to one if the firm belongs to a group): being a member of a group can facilitate knowledge spillovers. Intra-group flows of resources may be an important option for funding investment projects so that firms that are part of a group may have access to additional capital through their parent companies.

- Growth opportunities (proxied by the average annual growth rate of total assets): high growth firms are more likely to innovate.

- Fixed assets (measured by the ratio of fixed assets to total assets): the higher the degree of pledgeability of firm's assets the lower are financial constraints faced by innovative firms and the higher is the probability they introduce innovations.

- Export (proxied by a dummy variable equal to one whenever the firm has exported any of its products): the experience in international markets may foster R&D activity and promote innovation through learning effects (Bustos 2012)¹².

- Listed (proxied by a dummy variable equal to one if the firm is listed): listed firms are more likely to face less financial constraints and therefore to innovate.

In addition we controlled for the sector of activity (according to the Pavitt taxonomy) and for the country where the firm operates.

Table 4 reports summary statistics on the financial and control variables used to explain firms' innovative behaviour distinguishing between non-innovative and innovative firms and between non-R&D and R&D firms.

The table shows that innovative firms are on average larger, have slightly more fixed assets, are more likely to export, to belong to a group and to be listed (although the percentage remains very low) than non-innovative firms. Looking at the financial indicators, innovative firms have used more financial instruments, in particular more equity, bank credit (both short-term and medium/long-term), public funds, and leasing and factoring. Finally, both innovative and non-innovative firms are mainly concentrated in scale-intensive and supplier-dominated sector, but innovative firms are relatively more concentrated than non-innovative ones in the science-based and

¹² See also Siedschlag and Zhang (2015) that, based on data from Ireland over the period 2004-2008, find that firms with international activities are more likely to invest in innovation and at a higher intensity relative to firms that serve only domestic markets. Note that the association between export and innovation may also depend on reverse causality from innovation to export. Reverse causality may occur also for other control variables (e.g. growth) and cannot be tested in the absence of time-series data. However, in our view, it is not a big concern for our study since we are interested in assessing whether there is a robust association between proxies of relationship lending and innovation also when controlling for other variables that might differ across innovative and non-innovative firms.

specialised-suppliers sectors. When comparing R&D and non-R&D investors we find almost the same differences (often more marked) but R&D spenders are older than non-R&D firms, while there is no difference in fixed assets.

4. Econometric specification

In the empirical analysis, we estimate two models for innovation. In the first model (the extensive margin) the dependent variable is the dummy ‘innovation’, in the second model (the intensive margin) the dependent variable is the innovation intensity.

Let’s define y^* as the profit-maximising level of innovation intensity. This level can be zero whenever profits are higher in the absence of innovation. We assume that the optimal innovation intensity depends on the characteristics of bank-firm relationships, other financial variables and a set of control variables:

$$y^*_i = \alpha_0 + \alpha_1 R_i + \alpha_2 F_i + \alpha_3 C_i + \varepsilon_i \quad (1)$$

where R is a vector of variables capturing the strength of bank-firm relationships; F is a vector of variables capturing firm’s i financing characteristics; C is a vector of control variables; ε is a vector of residuals.

We then model the choice to innovate using a probit specification:

$$\text{Prob}(\text{INNOVATION} = 1)_i = \text{Prob}(y^* > 0)_i = \Phi(\alpha_0 + \alpha_1 R_i + \alpha_2 F_i + \alpha_3 C_i + \varepsilon_i) \quad (2)$$

where INNOVATION is equal to one if firm i answers ‘yes’ to the question: ‘In the last three years (2007-2009) has the firm carried out any product or process innovation?’ and zero otherwise, and Φ denotes the normal cumulative distribution function.

We also model the innovation intensity using a Tobit model:

$$\text{INNTURN} = \beta_0 + \beta_1 R_i + \beta_2 F_i + \beta_3 C_i + \zeta_i \quad (3)$$

where INNTURN indicates the turnover from innovative products sales over total turnover (average over the period 2007-2009), and ζ is a vector of residuals.

The formulation in terms of log-likelihood functions is:

$$\ln L = \sum_{y_i > 0} \ln \frac{1}{\sigma} \varphi \left(\frac{y_i - x_i \beta}{\sigma} \right) + \sum_{y_i = 0} \ln \left[1 - \Phi \left(\frac{\beta' x_i}{\sigma} \right) \right] \quad (4)$$

where φ and Φ respectively denote the normal density and standardised cumulated function and x are all the regressors. The model embeds both a classical regression of the impact of the explanatory variables on the innovation intensity (for the non-censored observations) and the probability of the positive outcome. In the tables of results we will report marginal effects on the innovation intensity conditional on the positive outcome: $\frac{\partial E(y^* | y^* > 0, x)}{\partial x}$.

Finally, in order to disentangle the channels whereby relationship lending affects innovation, we relate firms' credit needs and firms' credit rationing to our measures of relationship lending. In particular, similarly to Frazzoni et al. (2014), we estimate the following bivariate probit model with selection:

$$\text{Prob}(\text{MORECREDIT}=1)_i = \Phi(\gamma_0 + \gamma_1 R_i + \gamma_2 F_i + \gamma_3 C_i + \psi_i) \quad (5a)$$

$$\text{Prob}(\text{RATIONED}=1)_i = \Phi(\delta_0 + \delta_1 R_i + \delta_2 F_i + \delta_3 C_i + \omega_i) \quad (5b)$$

where MORECREDIT is equal to one if the firm i answers 'yes' to the question: 'During the last year, was the firm willing to increase its borrowing at the same interest rate of its current credit line?', zero otherwise; RATIONED is observed only if MORECREDIT is equal to one and it is equal to one if the firm applied for more credit in the last year but was not successful, zero otherwise; the error terms ψ and ω are assumed to follow a bivariate standard normal distribution $(\psi, \omega) \sim N(0, 1)$ with correlation coefficient $\rho = \text{corr}(\psi, \omega)$.

5. Regression results

Table 5 reports the results for the extensive margin (or, following the terminology as in Giannetti (2012), 'the discovery phase') and for the intensive margin ('the introduction phase') for innovation.

Looking first at indicators of bank-firm relationships, we find that both soft-information intensive relationships and long-lasting relationships significantly increase the probability to innovate; also the number of banking relationships (less exclusive relationships) is associated with a higher probability to innovate, while the share of the main bank is not significant.

Overall these results are consistent with Micucci and Rossi (2013) and suggest opposite effects of information intensive (long-lasting and soft-information intensive) relationships and exclusive relationships. On the one hand, innovative firms, in order to overcome information asymmetries,

have to engage in strong relationships, on the other, in order either to avoid hold-up problems or to reduce credit constraints, prefer to have relationships with multiple lenders.

Looking at other financial variables, we find that the probability to innovate is positively affected by firms' cash-flow. This confirms the importance of internal funds for the financing of innovative activities. Among control variables, the size of the firm, being an exporter, fixed assets and growth opportunities positively affect innovation (at the extensive margin).

Looking at the intensive margin, we find the same pattern of association between our proxies for bank-firm relationships and firms' innovation intensity found for the extensive margin: soft-information intensive relationships, long-lasting relationships and the number of banking relationships positively affect innovation intensity, while the share of the main bank is not significant.

Similarly to the extensive margin, cash-flow has a positive impact on innovation intensity, which is (significantly) positively affected also by long-term leverage, that is the introduction of an innovation is mainly financed by internal funds, but the firm needs to have a more stable financing as the intensity of innovation increases. Exporting firms and high growth firms have also a higher intensity of innovation, while, differently from the probability to innovate, innovation at the intensive margin does not depend on firms' size.

These results show that innovative activity of all firms is strongly related to the capability of banks to maintain their traditional role of generating private information about borrowers, while having a main bank holding a high share of debt has no impact on it. However, the positive effect of the number of banking relationships suggests that innovative firms react to credit rationing or to insurance concerns by resorting to multiple lending (Detragiache, Garella and Guiso 2000). Furthermore, innovative firms with multiple banking relationships might have access to a wider range of services and a more stable financing (a firm having relationships with more than one bank does not depend exclusively by the subjective evaluation of a loan officer, who might underestimate the probability of success of an innovative investment project).

Having assessed the role of strong relationships in stimulating the firm's propensity to innovate and the intensity of its innovation activity, we now ask through which channels relationship lending affects firms' innovativeness. Alessandrini, Presbitero and Zazzaro (2010) distinguish between two channels: financial constraints and relational services. The first channel consists in the financial support given by relationship banks to innovative firms that helps in relaxing credit constraints. The second channel consists in a wider relation-based support to the innovative vein of the entrepreneur and his new production strategy. In order to discriminate between these two hypotheses we estimate whether relationship lending, measured along the soft information, time and exclusivity dimensions,

reduces credit constraints more for innovative than for non-innovative firms. This also helps in understanding the motivation for multiple relationships.

Table 6 reports the results of the estimation of equations (5a) and (5b) for all firms and distinguishing between innovative and non-innovative firms. From the table we can observe that firms having soft-information intensive relationships demand more credit. Moreover, the demand for credit increases with the number of banking relationships, with long-term leverage and with firms' fixed assets, while it decreases with firms' cash-flow. Among firms demanding more credit, those that have long-lasting relationships with banks and those with soft-information intensive relationships are less credit constrained. The same occurs for firms with more banking relationships but also with a higher share of the main bank. Overall, it appears that there are two complementary strategies for firms to reduce credit constraints: engaging in stronger bank-firm relationships and having multiple creditors. But are there differences in the effectiveness of these strategies between innovative and non-innovative firms?

Regression results show that for innovative firms the only successful strategy to reduce credit constraints is to engage in relationships with banks that use soft information, while for firms that do not innovate there appear to be two complementary strategies for reducing credit constraints: engaging in multiple banking relationships and maintaining long-lasting relationships with the main bank.

Overall, the results on soft information support the existence of a financial channel relating the use of soft information with firms' innovativeness. Innovative firms are less transparent and more risky so that only banks spending resources in accurately screen their investment projects are able to provide them with the required amount of funding. Differently from the use of soft information, the results for the time dimension of the relationship are less clear-cut. In particular, for innovative firms long-lasting relationships do not appear to reduce credit constraints. In this case, the positive association between long-lasting relationships and innovation might depend on a wider relation-based support to the innovativeness of the entrepreneur (Alessandrini, Presbitero and Zazzaro 2010). Moreover, the results on the number of banking relationships suggest that innovative firms do not reduce credit constraints by engaging in multiple banking relationships. Therefore, possibly they diversify the lending banks in order to be insured against a reduction of credit supply by the main bank: for innovative firms switching costs are prohibitive and a decrease in credit granted may cause the firm exiting from the market (Micucci and Rossi 2013).

6. Robustness tests

In order to check the robustness of our findings for innovation at the extensive and intensive margins, we run several tests. Specifically, since the empirical research has more often identified innovative firms as undertaking some R&D activity, in table 7 we use the alternative identification of innovative firms based on R&D investments.

We find that, when firms' innovativeness is measured by formal R&D activity, only soft-information intensive relationships significantly increase innovation at the extensive and intensive margins, while long-lasting relationships do not significantly affect the probability to undertake R&D nor its intensity. Thus for R&D firms the actual use of soft information appears to be more important than the potential use proxied by long-lasting relationships. This result possibly reflects the greater uncertainty of R&D activity (R&D firms have not had an output from innovation yet and it is not sure they will have) and shows that our findings for the role of the soft-information dimension of relationship lending in fostering innovation are robust to definition of innovative firms. Again multiple relationships are associated with more innovation at both extensive and intensive margins, while credit concentration as measured by the share of the main bank does not affect innovation¹³.

In table 8 we control for the financial instruments used by the firm in order to satisfy its financing needs for the restricted sample of firms for which we have this information (those firms that answer to the survey question: 'What kind of financial instruments have been used to satisfy your firm's financing needs?'). Specifically, we estimate the same model for innovation (identified on the basis of both product or process innovation and R&D investments) on this sample including a dummy variable for each financial instrument (Equity, Venture capital and private equity, Short-term bank credit, Medium- or long-term bank credit, Securities, Public funds, Tax incentives, Leasing or factoring) as financial factors that possibly affect innovation.

Also for this restricted sample only the actual use of soft information is robustly positively associated with innovation and R&D at both extensive and intensive margins, while long-lasting relationships positively affect the probability both to innovate and to invest in R&D but not their intensities. The number of banking relationships loses significance (although the share of the main bank turns out to negatively affect the probability to invest in R&D). Among financial instruments, a higher use of equities makes firms more likely to introduce a product or process innovation and firms that innovate do it more intensively. Tax incentives have the same positive effect on the probability to undertake R&D and on R&D intensity. It is worth noticing that public funds

¹³We also estimate credit rationing for R&D and non-R&D firms and we find the same results as for innovative firms, with a higher significance of the soft-information indicator for R&D firms. Results are available on request.

(significantly) positively affect only the probability to innovate and, more interestingly, that venture capital and private equity significantly increase the intensity of both innovation and R&D. These results outline the importance of national and European policies in supporting innovation¹⁴ and also suggest that venture capital may play an important role in increasing the degree of innovativeness of European firms.

Finally, in table 9 we conduct our analysis (on both innovation and R&D) restricting the sample to small firms (up to 50 employees) since small firms are supposed to benefit more than other firms from strong bank-firm relationships. Again we find that soft-information intensive relationships significantly increase innovation at the extensive and intensive margins (for both definitions of innovation). We also find some (weaker) evidence that long-lasting relationships favour innovation (they do not affect R&D intensity) and that multiple relationships positively affect innovation at the extensive and intensive margins (not R&D at the intensive margin), while the share of the main bank is again not significant.

Focussing on the soft-information indicator, we can compare the size of its impact on innovation and R&D for the whole sample (tables 5 and 7) and for small firms (table 9). Soft-information intensive relationships increase the probability to innovate by 6% and the probability to undertake R&D by about 9% for the whole sample. These percentages are even (slightly) higher in the case of small firms (respectively 7% and 10%). Moreover, conditional on being innovative, all firms with soft-information intensive relationships increase the intensities at which they innovate by 29% and undertake R&D activities by about 20%, and these effects are even larger for small firms (33% and 22% respectively). These results show that firm's innovative activity is strongly related to the capability of banks to maintain the traditional role of generating private information about borrowers, and this is especially true in the case of small firms for which information asymmetries are particularly severe.

Overall our tests reveal that the positive effect of the soft-information dimension of relationship lending is strong and robust, while that of the time dimension is weaker and less robust. The effect of the exclusivity dimension is less clear-cut: the share of the main bank is almost ineffective, while multiple (less exclusive) relationships seem to stimulate innovation.

In conclusion our findings suggest that, more than the long-lasting relationship and therefore the fact that the bank knows the firm, what really matters for innovation is the kind of information the bank actually uses in the evaluation of the single investment projects of the loan applicant. This supports our choice of the soft-information indicator as a better proxy for relationship lending:

¹⁴ Silva and Carreira (2012) find that financial constraints have a perverse effect upon R&D investment and innovation but no evidence that subsidies mitigate such constraints. Accordingly, they raise a number of questions regarding the efficiency and effectiveness of subsidies in alleviating firms' financial constraints.

focussing on the time dimension of relationship lending (long-lasting relationships) may result in an under-estimation of the effect of relationship lending on innovation and focussing on the exclusivity dimension (the number of banking relationships and the share of the main bank) may get to misleading results such as excluding a positive role of relationship lending in favouring innovation.

7. Conclusions

Evaluating innovative ideas is not an easy task to a bank. Our results demonstrate that relationship lending may be an effective way to overcome the disadvantage of bank loans in the financing of innovation. Using a detailed dataset covering the four largest bank-based European countries (Germany, France, Italy and Spain), we document that the use of soft information has a robust positive effect both on firms' probability to innovate and on their innovation intensity. Furthermore, soft information helps innovative firms to reduce credit rationing, suggesting that soft-information intensive relationships favour innovation through a financial channel. When we look at the impact of long-lasting relationships on innovation we find a positive but not robust effect. We also find that they do not help in reducing credit constraints for innovative firms. This suggests that firms choosing their main banks because they have a long-lasting-relationship are more likely to innovate because of a mechanism different from the financial channel (e.g. wider relation-based support by the bank to the innovative vein of the entrepreneur).

Credit concentration as measured by the number of banking relationships is negatively related to innovation, while the share of the main bank has no effect. Also our results show that multiple banking relationships are not a successful strategy to reduce credit constraints for innovative firms, while it is so for non-innovative firms, suggesting that innovative firms may tend to diversify the lending banks in order to be insured against a reduction of credit supply by the main bank.

Our robustness tests show that the choice of the proxy for relationship lending is very important: proxies based on the time dimension of relationship lending (long-lasting relationships) may result in an under-estimation of the effect of relationship lending on innovation, while those based on the exclusivity dimension (the number of banking relationships and the share of the main bank) may get to misleading results such as excluding a positive role of relationship lending in favouring innovation. Only our soft-information indicator, that is a direct measure of the type of information the bank uses in order to assess the borrower's creditworthiness, has a robust positive relationship with innovation.

We can conclude that a bank using interviews with firms' managers and evaluations of their business plans when assessing the firm's creditworthiness tends to foster innovation and this is the kind of bank that may still perform the Schumpeterian role of 'ephor' of capitalism. Therefore, the

ongoing substitution of traditional relationship lending technologies with screening technologies based on standardised internal rating models that use mainly hard information may hamper firms' innovation. This should cause particular concern in European bank-based systems where firms strongly rely on bank credit to finance innovation. Moreover, during downturns, firms have difficulties to resort to self-financing so that it becomes even more important to ensure the presence of a counter-cyclical financing channel for innovative firms. In the absence of such channel, negative shocks to the economy, by reducing the financing of innovation, may have negative consequences also on long-run growth.

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Appendix

Survey questions

- F12. Which factors are key in the choice of a **main bank**? (*spontaneous do not read out*)
- the bank offers competitive services and funding
 - the bank offers efficient internet services
 - the bank's lending criteria is clear and transparent
 - the bank is conveniently located
 - the bank has an extensive international network
 - the bank offers also a consultancy on strategic financial decisions
 - the bank has a long-lasting relationship with the firm
 - the bank has flexible procedures/not constrained by red tape
 - it was the Group's main bank
 - other
- F16. Which type of information does the bank normally use/ask to *assess* your firm's credit worthiness? (*read out*)
- Collateral
 - Balance sheet information
 - Interviews with management on firm's policy and prospects
 - Business plan and firms' targets
 - Historical records of payments and debt service
 - Brand recognition
 - Other

Table A. Definition of variables

| Variables | Definition |
|--|--|
| <i>Innovation variables</i> | |
| Innovation | Dummy variable=1 if the firm carried out any product and/or process innovation in the last three years, =0 otherwise (question C14) |
| Innovation intensity | Average percentage of turnover from innovative products sales on average in the last three years (question C15) |
| R&D | Dummy variable=1 if the firm has undertaken any R&D activities in the last three years, =0 otherwise (question C20) |
| R&D intensity | Percentage of the total turnover that the firm has invested in R&D on average in the last three years (question C21) |
| <i>Credit rationing variables</i> | |
| More credit | Dummy variable=1 if the firm was willing to increase its borrowing at the same interest rate of its current credit line during the last year, =0 otherwise (question F13) |
| Rationed | Dummy variable=1 if the firm was willing more credit and applied for it during the last year but it was not successful, =0 otherwise (question F14) |
| <i>Bank-firm relationships variables</i> | |
| Number of banks | Number of banking relationships (question F9) |
| Share of main bank | Percentage of firm's total bank debt held at the main bank (question F10) |
| Long-lasting relationships | Dummy variable=1 if the key factor in the firm's choice of a main bank is the bank having a long-lasting relationship with the firm, =0 otherwise (question F12) |
| Soft | Dummy variable=1 if the firm's bank normally uses/asks interviews with management on firm's policy and prospects and/or business plan and firms' targets in order to assess the firm's creditworthiness, =0 otherwise (question F16) |
| <i>Control variables</i> | |
| Age | Number of years since the firm has been established |
| Export | Dummy variable=1 if the firm has exported any of its products before 2008, =0 otherwise (question D5) |
| Fixed assets | Ratio of fixed assets to total assets |
| Group membership | Dummy variable=1 if the firm belongs to a group, =0 otherwise (question A8) |
| Growth | Average annual growth rate of total assets between 2004 and 2007 |
| Listed | Dummy variable=1 if the firm is listed on a stock exchange, =0 otherwise (question F19) |
| Size | Number of employees |
| <i>Financial variables</i> | |
| Long-term leverage | Ratio of long-term debt to total assets |
| Short-term leverage | Ratio of short-term debt to total assets |
| Cash-flow | Ratio of cash-flow to total assets |
| Financial instrument dummies: | |
| Equity, Venture capital and private equity, Short-term bank credit, Medium- and long-term bank credit, Securities, Public funds, Tax incentives, Leasing and factoring | Dummy variables=1 if, in order to satisfy its financing needs, the firm has used the specified instrument, =0 otherwise (question F6) |
| <i>Country dummies</i> | |
| France, Germany, Italy, Spain | Dummy variables=1 if the firm operates in the specified country, =0 otherwise |
| <i>Sector dummies</i> | |
| Supplier-dominated, Science-based, Scale-intensive, Specialised suppliers | Dummy variables=1 if the firm operates in the specified sector, =0 otherwise |

Notes: Data are taken from the EFIGE Bruegel-Unicredit dataset. The survey has been run in early 2010. The questionnaire data are integrated with balance sheet data drawn from the Amadeus database managed by Bureau van Dijk. Balance sheet data refers to 2007.

Table 1. Frequencies, intensities and financing sources of innovation and R&D by countries

| <i>Panel A: Innovation</i> | France | Germany | Italy | Spain |
|-------------------------------|--------|---------|-------|-------|
| Innovative firms (%) | 56 | 65 | 67 | 70 |
| Intensity (%) | 9.21 | 11.89 | 14.28 | 12.24 |
| <i>Financing sources (%):</i> | | | | |
| Self-financing | 50.56 | 55.93 | 49.55 | 39.15 |
| Intra-group financing | 4.47 | 5.78 | 0.77 | 3.42 |
| Venture capital | 0.68 | 0.56 | 0.13 | 0.39 |
| Bank credit | 30.39 | 22.44 | 23.94 | 32.45 |
| Public funding | 1.69 | 2.34 | 1.82 | 3.12 |
| Leasing and factoring | 10.10 | 12.10 | 23.07 | 19.54 |
| Other | 2.08 | 0.85 | 0.73 | 1.94 |
| <i>Panel B: R&D</i> | France | Germany | Italy | Spain |
| R&D firms (%) | 51 | 55 | 55 | 46 |
| Intensity (%) | 3.15 | 4.25 | 3.99 | 3.24 |
| <i>Financing sources (%):</i> | | | | |
| Self-financing | 72.04 | 72.76 | 73.20 | 59.74 |
| Intra-group financing | 3.98 | 6.46 | 0.99 | 3.76 |
| Venture capital | 0.37 | 0.37 | 0.16 | 0.20 |
| Bank credit | 14.24 | 12.24 | 14.99 | 18.73 |
| Public funding | 3.85 | 2.68 | 2.46 | 5.79 |
| Leasing and factoring | 3.75 | 4.09 | 7.12 | 9.07 |
| Other | 1.63 | 1.41 | 1.08 | 2.71 |

Notes: In panel A innovative firms are firms that report having carried out any product and/or process innovation in the period 2007-2009; innovation intensity is measured as the percentage of turnover from innovative products sales (on average between 2007 and 2009); financing sources of innovation refer to the financing of investments in plants, machines, equipment, ICT for innovative firms. In panel B R&D firms are firms that report having undertaken any R&D activities in the period 2007-2009; R&D intensity is measured as the percentage of total turnover invested in R&D (on average between 2007 and 2009); financing sources of R&D refer to the financing of R&D investments. Sample countries are France, Germany, Italy and Spain.

Table 2. Which type of information does the bank normally use/ask to assess your firm's credit worthiness?

| <i>Soft information</i> | <i>Hard information</i> |
|---|---|
| Interviews with management on firm's policy and prospects | Collateral |
| Business plan and firm's targets | Balance sheet information |
| | Historical records of payments and debt service |
| | Brand recognition |
| | Other |

Notes: The table classifies answers to question F16 of the EFIGE questionnaire as soft and hard information.

Table 3. Summary statistics on the indicators of bank-firm relationships by type of firms

| <i>Panel A: Innovation</i> | <i>Non-innovative firms</i> | | <i>Innovative firms</i> | | Mean diff. | t-test |
|----------------------------|-----------------------------|-----------|-------------------------|-----------|--------------|----------|
| | Mean | Std. Dev. | Mean | Std. Dev. | | |
| Number of banks | 3.00 | 2.23 | 3.72 | 2.81 | -0.72 | -14.0654 |
| Share of main bank | 57.57 | 31.32 | 53.63 | 30.56 | 3.94 | 4.3681 |
| Long-lasting relationships | 0.62 | 0.49 | 0.63 | 0.48 | -0.01 | -0.8319 |
| Soft | 0.58 | 0.49 | 0.65 | 0.48 | -0.07 | -5.1574 |
| <i>Panel B: R&D</i> | <i>Non-R&D firms</i> | | <i>R&D firms</i> | | Mean diff. | t-test |
| | Mean | Std. Dev. | Mean | Std. Dev. | | |
| Number of banks | 3.11 | 2.21 | 3.79 | 2.95 | -0.68 | -13.8981 |
| Share of main bank | 57.82 | 31.09 | 52.25 | 30.40 | 5.57 | 6.7257 |
| Long-lasting relationships | 0.63 | 0.48 | 0.62 | 0.49 | 0.01 | 0.5168 |
| Soft | 0.55 | 0.50 | 0.69 | 0.46 | -0.14 | -10.4560 |

Notes: Data are pooled across countries. Variables are defined in the Appendix (table A). Types of firms are: non-innovative and innovative firms (panel A) and non-R&D and R&D firms (panel B). Significant (at 1% level) mean differences are reported in bold.

Table 4. Summary statistics on other financial and control variables by type of firms

| <i>Panel A: Innovation</i> | <i>Non-innovative firms</i> | | | | <i>Innovative firms</i> | | | |
|------------------------------------|-----------------------------|-----------|-------|------|-------------------------|-----------|-------|------|
| | Mean | Std. Dev. | Min | Max | Mean | Std. Dev. | Min | Max |
| <i>Financial variables:</i> | | | | | | | | |
| Long-term leverage | 0.20 | 0.22 | 0 | 0.99 | 0.21 | 0.21 | 0 | 0.99 |
| Short-term leverage | 0.47 | 0.25 | 0 | 1.26 | 0.46 | 0.24 | 0 | 1.27 |
| Cash-flow | 0.08 | 0.08 | -0.23 | 0.38 | 0.08 | 0.07 | -0.22 | 0.38 |
| <i>Financial instruments:</i> | | | | | | | | |
| Equity | 0.13 | 0.34 | 0 | 1 | 0.18 | 0.39 | 0 | 1 |
| Venture capital and private equity | 0.02 | 0.13 | 0 | 1 | 0.03 | 0.18 | 0 | 1 |
| Short-term bank credit | 0.40 | 0.49 | 0 | 1 | 0.44 | 0.50 | 0 | 1 |
| Medium- and long-term bank credit | 0.70 | 0.46 | 0 | 1 | 0.74 | 0.44 | 0 | 1 |
| Securities | 0.02 | 0.14 | 0 | 1 | 0.04 | 0.20 | 0 | 1 |
| Public funds | 0.06 | 0.23 | 0 | 1 | 0.10 | 0.29 | 0 | 1 |
| Tax incentives | 0.03 | 0.17 | 0 | 1 | 0.05 | 0.22 | 0 | 1 |
| Leasing or factoring | 0.27 | 0.44 | 0 | 1 | 0.31 | 0.46 | 0 | 1 |
| <i>Control variables:</i> | | | | | | | | |
| Size | 47 | 86 | 1 | 1040 | 69 | 122 | 1 | 1113 |
| Age | 34 | 29 | 0 | 189 | 35 | 31 | 0 | 368 |
| Group membership | 0.18 | 0.38 | 0 | 1 | 0.23 | 0.42 | 0 | 1 |
| Fixed assets | 0.27 | 0.20 | 0 | 0.98 | 0.30 | 0.20 | 0 | 0.99 |
| Export | 0.51 | 0.50 | 0 | 1 | 0.72 | 0.45 | 0 | 1 |
| Listed | 0.01 | 0.12 | 0 | 1 | 0.02 | 0.13 | 0 | 1 |
| Growth | 0.05 | 0.09 | -0.35 | 0.28 | 0.06 | 0.09 | -0.35 | 0.28 |
| <i>Sector dummies:</i> | | | | | | | | |
| Supplier-dominated | 0.20 | 0.40 | 0 | 1 | 0.20 | 0.40 | 0 | 1 |
| Science-based | 0.12 | 0.33 | 0 | 1 | 0.15 | 0.36 | 0 | 1 |
| Scale-intensive | 0.55 | 0.50 | 0 | 1 | 0.47 | 0.50 | 0 | 1 |
| Specialised suppliers | 0.12 | 0.33 | 0 | 1 | 0.18 | 0.38 | 0 | 1 |
| <i>Country dummies:</i> | | | | | | | | |
| France | 0.30 | 0.46 | 0 | 1 | 0.21 | 0.41 | 0 | 1 |
| Germany | 0.25 | 0.43 | 0 | 1 | 0.25 | 0.44 | 0 | 1 |
| Italy | 0.24 | 0.43 | 0 | 1 | 0.27 | 0.45 | 0 | 1 |
| Spain | 0.21 | 0.41 | 0 | 1 | 0.27 | 0.44 | 0 | 1 |

Table 4 – Summary statistics on other financial and control variables by type of firms - continued

| <i>Panel B: R&D</i> | <i>Non-R&D firms</i> | | | | <i>R&D firms</i> | | | |
|------------------------------------|--------------------------|-----------|-------|------|----------------------|-----------|-------|------|
| | Mean | Std. Dev. | Min | Max | Mean | Std. Dev. | Min | Max |
| <i>Financial variables:</i> | | | | | | | | |
| Long-term leverage | 0.20 | 0.21 | 0 | 0.99 | 0.21 | 0.21 | 0 | 0.99 |
| Short-term leverage | 0.47 | 0.25 | 0 | 1.27 | 0.46 | 0.25 | 0 | 1.25 |
| Cash-flow | 0.08 | 0.07 | -0.23 | 0.38 | 0.08 | 0.07 | -0.22 | 0.37 |
| <i>Financial instruments:</i> | | | | | | | | |
| Equity | 0.14 | 0.35 | 0 | 1 | 0.19 | 0.39 | 0 | 1 |
| Venture capital and private equity | 0.02 | 0.14 | 0 | 1 | 0.04 | 0.19 | 0 | 1 |
| Short-term bank credit | 0.42 | 0.49 | 0 | 1 | 0.44 | 0.50 | 0 | 1 |
| Medium- and long-term bank credit | 0.72 | 0.45 | 0 | 1 | 0.74 | 0.44 | 0 | 1 |
| Securities | 0.03 | 0.17 | 0 | 1 | 0.04 | 0.19 | 0 | 1 |
| Public funds | 0.07 | 0.25 | 0 | 1 | 0.10 | 0.30 | 0 | 1 |
| Tax incentives | 0.02 | 0.15 | 0 | 1 | 0.06 | 0.24 | 0 | 1 |
| Leasing or factoring | 0.30 | 0.46 | 0 | 1 | 0.30 | 0.46 | 0 | 1 |
| <i>Control variables:</i> | | | | | | | | |
| Size | 43 | 80 | 1 | 1106 | 79 | 132 | 1 | 1113 |
| Age | 33 | 28 | 0 | 159 | 37 | 32 | 0 | 368 |
| Group membership | 0.15 | 0.36 | 0 | 1 | 0.26 | 0.44 | 0 | 1 |
| Fixed assets | 0.29 | 0.20 | 0 | 0.98 | 0.29 | 0.19 | 0 | 0.99 |
| Export | 0.49 | 0.50 | 0 | 1 | 0.79 | 0.41 | 0 | 1 |
| Listed | 0.01 | 0.10 | 0 | 1 | 0.02 | 0.15 | 0 | 1 |
| Growth | 0.05 | 0.09 | -0.35 | 0.28 | 0.05 | 0.09 | -0.35 | 0.28 |
| <i>Sector dummies:</i> | | | | | | | | |
| Supplier-dominated | 0.22 | 0.41 | 0 | 1 | 0.19 | 0.39 | 0 | 1 |
| Science-based | 0.12 | 0.32 | 0 | 1 | 0.17 | 0.37 | 0 | 1 |
| Scale-intensive | 0.56 | 0.50 | 0 | 1 | 0.44 | 0.50 | 0 | 1 |
| Specialised suppliers | 0.11 | 0.31 | 0 | 1 | 0.21 | 0.41 | 0 | 1 |
| <i>Country dummies:</i> | | | | | | | | |
| France | 0.25 | 0.43 | 0 | 1 | 0.23 | 0.42 | 0 | 1 |
| Germany | 0.24 | 0.43 | 0 | 1 | 0.27 | 0.44 | 0 | 1 |
| Italy | 0.24 | 0.43 | 0 | 1 | 0.28 | 0.45 | 0 | 1 |
| Spain | 0.27 | 0.45 | 0 | 1 | 0.22 | 0.41 | 0 | 1 |

Notes: Data are pooled across countries. Variables are defined in the Appendix (table A). Types of firms are: non-innovative and innovative firms (panel A) and non-R&D and R&D firms (panel B).

Table 5. Determinants of innovation: extensive and intensive margins

| Variables | Extensive margin (Probit model) | Intensive margin (Tobit model) |
|----------------------------------|------------------------------------|-----------------------------------|
| | Innovation (1/0) | Innovation intensity |
| Number of banks | 0.0344** (0.0149) | 0.1212** (0.0626) |
| Share of main bank | -0.0095 (0.0073) | -0.0022 (0.0312) |
| Long-lasting relationships (1/0) | 0.0415*** (0.0155) | 0.1286** (0.0654) |
| Soft (1/0) | 0.0602*** (0.0158) | 0.2896*** (0.0670) |
| Long-term leverage | 0.1254 (0.0785) | 0.9181*** (0.3302) |
| Short-term leverage | -0.0328 (0.0715) | -0.1492 (0.3031) |
| Cash-flow | 0.3792*** (0.1375) | 1.0197* (0.5852) |
| Size | 0.0183* (0.0102) | 0.0394 (0.0407) |
| Age | 0.0007 (0.0113) | -0.0648 (0.0473) |
| Group membership (1/0) | 0.0275 (0.0217) | 0.1056 (0.0869) |
| Fixed assets | 0.1362** (0.0623) | 0.4088 (0.2605) |
| Export (1/0) | 0.1215*** (0.0160) | 0.6958*** (0.0728) |
| Listed (1/0) | 0.0807 (0.0861) | 0.4101 (0.3151) |
| Growth | 0.1986** (0.0888) | 0.7765** (0.3750) |
| Supplier-dominated (1/0) | -0.0311 (0.0259) | -0.1695* (0.1014) |
| Science-based (1/0) | 0.0473 (0.0298) | -0.1276 (0.1158) |
| Scale-intensive (1/0) | -0.0787*** (0.0230) | -0.6146*** (0.0921) |
| Germany (1/0) | -0.0415 (0.0660) | -0.3428 (0.2865) |
| Italy (1/0) | 0.0948*** (0.0253) | 0.3853*** (0.1080) |
| Spain (1/0) | 0.0914*** (0.0246) | 0.2314** (0.1060) |
| Number of observations | 3615 | 2809 |
| Log-likelihood | -2059.42 | -4626.78 |
| Estimated probability | 0.7137 | |

Notes: Figures reported in the table are marginal effects. Standard errors are in parentheses. Innovation is equal to 1 if a firm reports to have carried out any product and/or process innovation and 0 otherwise. Innovation intensity is the logarithm of one plus the innovation intensity. Number of banks, size and age are in logarithm. Share of main bank, long-term leverage, short-term leverage, cash-flow, fixed assets and growth are the logarithm of one plus the specified variable. The (1/0) notation denotes dummy variables. Base category for Pavitt sectors is specialised suppliers. Base category for countries is France. *, **, *** denote respectively significant at 10%, 5% and 1%.

Table 6. Determinants of demand for credit and credit rationing: Heckman selection model

| Variables | All firms | | Innovative firms | | Non-innovative firms | |
|----------------------------------|----------------------|-------------------|----------------------|-------------------|----------------------|-------------------|
| | More credit (1/0) | Rationed (1/0) | More credit (1/0) | Rationed (1/0) | More credit (1/0) | Rationed (1/0) |
| Number of banks | 0.249*** (0.046) | -0.163*** (0.057) | 0.218*** (0.055) | -0.092 (0.073) | 0.325*** (0.089) | -0.355*** (0.106) |
| Share of main bank | 0.026 (0.023) | -0.055** (0.029) | 0.039 (0.027) | -0.051 (0.033) | -0.002 (0.045) | -0.081 (0.071) |
| Long-lasting relationships (1/0) | 0.018 (0.047) | -0.091* (0.055) | 0.001 (0.056) | -0.034 (0.066) | 0.037 (0.088) | -0.215* (0.112) |
| Soft (1/0) | 0.130*** (0.047) | -0.105* (0.055) | 0.146*** (0.056) | -0.114* (0.067) | 0.085 (0.092) | -0.044 (0.105) |
| Long-term leverage | 1.576*** (0.240) | -0.556 (0.362) | 1.528*** (0.286) | -0.551 (0.466) | 1.663*** (0.459) | -0.341 (0.700) |
| Short-term leverage | 1.928 (0.227) | -0.224 (0.471) | 2.019*** (0.272) | -0.115 (0.674) | 1.880*** (0.431) | -0.338 (0.801) |
| Cash-flow | -2.835*** (0.429) | 0.636 (0.657) | -2.846*** (0.521) | 0.827 (0.776) | -2.898*** (0.817) | 0.016 (1.786) |
| Size | -0.024 (0.030) | 0.045 (0.035) | -0.038 (0.034) | 0.039 (0.041) | 0.007 (0.063) | 0.066 (0.089) |
| Age | 0.038 (0.034) | 0.003 (0.039) | -0.028 (0.040) | 0.015 (0.047) | -0.066 (0.065) | 0.012 (0.077) |
| Group membership (1/0) | 0.000 (0.063) | 0.131* (0.077) | 0.090 (0.073) | 0.042 (0.090) | -0.311** (0.134) | 0.513*** (0.178) |
| Fixed assets | 0.592*** (0.187) | -0.162 (0.245) | 0.506** (0.225) | 0.082 (0.318) | 0.756** (0.351) | -0.682 (0.433) |
| Export (1/0) | 0.048 (0.050) | -0.061 (0.059) | 0.022 (0.062) | -0.054 (0.074) | 0.074 (0.090) | -0.032 (0.105) |
| Listed (1/0) | 0.368 (0.233) | -0.324 (0.274) | 0.289 (0.256) | -0.162 (0.309) | 0.623 (0.582) | 5.037 (289.00) |
| Growth | -0.375 (0.268) | -0.475 (0.332) | -0.361 (0.318) | -0.604 (0.416) | -0.569 (0.512) | 0.015 (0.612) |
| Supplier-dominated (1/0) | -0.026 (0.076) | 0.160* (0.092) | -0.013 (0.088) | 0.112 (0.108) | -0.073 (0.155) | 0.313* (0.191) |
| Science-based (1/0) | -0.128 (0.086) | 0.144 (0.103) | -0.072 (0.097) | 0.100 (0.118) | -0.366* (0.194) | 0.226 (0.247) |
| Scale-intensive (1/0) | 0.015 (0.068) | 0.086 (0.083) | 0.065 (0.079) | 0.009 (0.097) | -0.119 (0.140) | 0.294 (0.172) |
| Germany (1/0) | 0.821*** (0.209) | -0.976*** (0.301) | 0.790*** (0.257) | -2.995 (77.794) | 0.872** (0.366) | -0.649 (0.548) |
| Italy (1/0) | 0.171** (0.082) | -0.029 (0.122) | 0.067 (0.098) | -0.012 (0.136) | 0.382 (0.153) | -0.068 (0.368) |
| Spain (1/0) | 0.511*** (0.080) | -0.196 (0.140) | 0.477*** (0.096) | -0.236 (0.156) | 0.533*** (0.150) | -0.059 (0.414) |
| Atrho | -1.748*** (0.471) | | -1.684*** (0.595) | | -1.954 (1.416) | |
| LR rho=0 | 5.93*** | | 3.48* | | 1.81 | |
| Number of observations | 3612 | | 2569 | | 1043 | |
| Log-likelihood | -2970.21 | | -2134.64 | | -807.85 | |

Notes: Figures reported in the table are estimated coefficients for the whole sample (column 1), for innovative firms (column 2) and for non-innovative firms (column 3). Standard errors are in parentheses. More credit is equal to 1 if a firm reports to be willing to increase its borrowing and 0 otherwise. Rationed is equal to 1 if, conditional on more credit =1, a firm reports it has applied for it but it was not successful and 0 otherwise. Number of banks, size and age are in logarithm. Share of main bank, long-term leverage, short-term leverage, cash-flow, fixed assets and growth are the logarithm of one plus the specified variable. The (1/0) notation denotes dummy variables. Base category for Pavitt sectors is specialised suppliers. Base category for countries is France. *, **, *** denote respectively significant at 10%, 5% and 1%.

Table 7. Determinants of R&D: extensive and intensive margins

| | Extensive margin (Probit model) | Intensive margin (Tobit model) |
|----------------------------------|------------------------------------|-----------------------------------|
| Variables | R&D (1/0) | R&D intensity |
| Number of banks | 0.0487*** (0.0160) | 0.0652* (0.0351) |
| Share of main bank | -0.0126 (0.0079) | -0.0050 (0.0173) |
| Long-lasting relationships (1/0) | 0.0224 (0.0165) | 0.0347 (0.3640) |
| Soft (1/0) | 0.0949*** (0.0165) | 0.1974*** (0.0370) |
| Long-term leverage | 0.0936 (0.0831) | 0.3993** (0.1852) |
| Short-term leverage | 0.0675 (0.0758) | 0.1117 (0.1700) |
| Cash-flow | 0.3013** (0.1475) | 0.8969*** (0.3224) |
| Size | 0.0454*** (0.0107) | 0.0251 (0.0225) |
| Age | 0.0015 (0.0118) | -0.0330 (0.0262) |
| Group membership (1/0) | 0.0654*** (0.0225) | 0.1041** (0.0476) |
| Fixed assets | 0.1318** (0.0662) | 0.3155** (0.1456) |
| Export (1/0) | 0.2171*** (0.0164) | 0.5158*** (0.0402) |
| Listed (1/0) | 0.0340 (0.0865) | 0.0468 (0.1758) |
| Growth | 0.1091 (0.0952) | 0.3022 (0.2083) |
| Supplier-dominated (1/0) | -0.1636*** (0.0267) | -0.4171*** (0.0575) |
| Science-based (1/0) | -0.0228 (0.0306) | -0.1081* (0.0635) |
| Scale-intensive (1/0) | -0.1868*** (0.0238) | -0.4557*** (0.0511) |
| Germany (1/0) | -0.1190* (0.0688) | -0.0964 (0.1566) |
| Italy (1/0) | 0.0543** (0.0273) | 0.1541*** (0.0593) |
| Spain (1/0) | -0.0297 (0.0265) | -0.0636 (0.0584) |
| Number of observations | 3615 | 3613 |
| Log-likelihood | -2226.35 | -4834.13 |
| Estimated probability | 0.6639 | |

Notes: Figures reported in the table are marginal effects. Standard errors are in parentheses. R&D is equal to 1 if a firm reports to have undertaken any R&D activities and 0 otherwise. R&D intensity is the logarithm of one plus the R&D intensity. Number of banks, size and age are in logarithm. Share of main bank, long-term leverage, short-term leverage, cash-flow, fixed assets and growth are the logarithm of one plus the specified variable. The (1/0) notation denotes dummy variables. Base category for Pavitt sectors is specialised suppliers. Base category for countries is France. *, **, *** denote respectively significant at 10%, 5% and 1%.

Table 8. Determinants of innovation and R&D controlling for financial instruments: extensive and intensive margins

| Variables | Extensive margin (Probit model) | | Intensive margin (Tobit model) | |
|--|------------------------------------|--------------------|-----------------------------------|--------------------|
| | Innovation (1/0) | R&D (1/0) | Innovation intensity | R&D intensity |
| Number of banks | -0.0079 (0.0238) | 0.0174 (0.0258) | -0.0020 (0.1036) | 0.0071 (0.0568) |
| Share of main bank | 0.0019 (0.0123) | -0.0306** (0.0133) | 0.0487 (0.0527) | -0.0264 (0.0289) |
| Long-lasting relationships (1/0) | 0.0538** (0.0232) | 0.0547** (0.0253) | 0.0971 (0.1011) | 0.0794 (0.0567) |
| Soft (1/0) | 0.0442* (0.0245) | 0.0844*** (0.0261) | 0.2509** (0.1064) | 0.2263*** (0.0589) |
| Long-term leverage | 0.2475** (0.1202) | 0.3704*** (0.1283) | 1.7945*** (0.5049) | 1.0163*** (0.2870) |
| Short-term leverage | 0.0908 (0.1109) | 0.1677 (0.1204) | 0.5407 (0.4724) | 0.2953 (0.2704) |
| Cash-flow | 0.4915** (0.2035) | 0.5301** (0.2212) | 1.9573** (0.9203) | 1.3954*** (0.4988) |
| Equity (1/0) | 0.0849** (0.0348) | 0.0435 (0.0363) | 0.3702*** (0.1387) | 0.0300 (0.0765) |
| Venture capital and private equity (1/0) | 0.1142 (0.0860) | 0.0818 (0.0807) | 0.6039** (0.3217) | 0.4451*** (0.1753) |
| Short-term bank credit (1/0) | 0.0018 (0.0241) | -0.0010 (0.0257) | -0.0419 (0.1030) | -0.0098 (0.0566) |
| Medium- and long-term bank credit (1/0) | 0.0107 (0.0286) | -0.0013 (0.0312) | -0.1003 (0.1247) | 0.0360 (0.0694) |
| Securities (1/0) | -0.0461 (0.1451) | -0.0005 (0.1326) | 0.2671 (0.5846) | 0.2058 (0.3708) |
| Public funds (1/0) | 0.0796* (0.0458) | 0.0038 (0.0462) | 0.0868 (0.1829) | 0.0219 (0.0993) |
| Tax incentives (1/0) | 0.0713 (0.0650) | 0.1645*** (0.0619) | 0.4883** (0.2290) | 0.3845*** (0.1303) |
| Leasing or factoring (1/0) | 0.0057 (0.0241) | -0.0373 (0.0261) | 0.0125 (0.1056) | -0.0881 (0.0574) |
| Size | 0.0245 (0.0157) | 0.0497*** (0.0163) | 0.0836 (0.0641) | 0.0206 (0.0355) |
| Age | 0.0030 (0.0171) | -0.0003 (0.0183) | -0.0190 (0.0735) | -0.0289 (0.0409) |
| Group membership (1/0) | 0.0043 (0.0329) | 0.0275 (0.0355) | 0.0716 (0.1372) | 0.0429 (0.0754) |
| Fixed assets | 0.1271 (0.0957) | 0.1849* (0.1052) | 0.3563 (0.4126) | 0.4238* (0.2299) |
| Export (1/0) | 0.1408*** (0.0245) | 0.2376*** (0.0252) | 0.7257*** (0.1148) | 0.5389*** (0.0634) |
| Growth | 0.2144 (0.1329) | 0.1802 (0.1445) | 0.9289 (0.5780) | 0.5100 (0.3198) |
| Number of observations | 1503 | 1503 | 1179 | 1503 |
| Log-likelihood | -890.27 | -904.43 | -1960.15 | -2010.65 |
| Estimated probability | 0.7325 | 0.6733 | | |

Notes: Figures reported in the table are marginal effects for the restricted sample of firms that report the kind of financial instruments used to satisfy their financing needs. Standard errors are in parentheses. Innovation is equal to 1 if a firm reports to have carried out any product and/or process innovation and 0 otherwise. R&D is equal to 1 if a firm reports to have undertaken any R&D activities and 0 otherwise. Innovation intensity is the logarithm of one plus the innovation intensity. R&D intensity is the logarithm of one plus the R&D intensity. Number of banks, size and age are in logarithm. Share of main bank, long-term leverage, short-term leverage, cash-flow, fixed assets and growth are the logarithm of one plus the specified variable. The (1/0) notation denotes dummy variables. Pavitt sectors and country dummies are included in the estimation. *, **, *** denote respectively significant at 10%, 5% and 1%.

Table 9. Determinants of innovation and R&D for small firms: extensive and intensive margins

| Variables | Extensive margin (Probit model) | | Intensive margin (Tobit model) | |
|----------------------------------|------------------------------------|---------------------|-----------------------------------|---------------------|
| | Innovation (1/0) | R&D (1/0) | Innovation intensity | R&D intensity |
| Number of banks | 0.0372* (0.0182) | 0.0393** (0.0193) | 0.1383* (0.0767) | 0.0481 (0.0434) |
| Share of main bank | -0.0077 (0.0086) | -0.0071 (0.0091) | -0.0025 (0.0368) | 0.0010 (0.0207) |
| Long-lasting relationships (1/0) | 0.0462*** (0.0179) | 0.0319* (0.0191) | 0.1426* (0.0763) | 0.0519 (0.0426) |
| Soft (1/0) | 0.0695*** (0.0181) | 0.0993*** (0.0189) | 0.3299*** (0.0766) | 0.2168*** (0.0425) |
| Long-term leverage | 0.0541 (0.0917) | 0.0659 (0.0971) | 0.5567 (0.3844) | 0.2774 (0.2176) |
| Short-term leverage | -0.0976 (0.0838) | 0.0018 (0.0883) | -0.2701 (0.3545) | -0.0212 (0.1993) |
| Cash-flow | 0.3224** (0.1612) | 0.3880** (0.1711) | 0.9154 (0.6873) | 1.1601*** (0.3815) |
| Size | 0.0135 (0.0196) | 0.0512*** (0.0201) | 0.0065 (0.0795) | 0.0687 (0.0444) |
| Age | -0.0158 (0.0136) | -0.0161 (0.0142) | -0.1250** (0.0570) | -0.0658** (0.0320) |
| Group membership (1/0) | 0.0150 (0.0293) | 0.0605** (0.0307) | 0.0506 (0.1199) | 0.1084* (0.0654) |
| Fixed assets | 0.1636** (0.0729) | 0.1529** (0.0777) | 0.5466* (0.3065) | 0.3724** (0.1728) |
| Export (1/0) | 0.1132*** (0.0180) | 0.2066*** (0.0185) | 0.6351*** (0.0805) | 0.4738*** (0.0449) |
| Listed (1/0) | 0.1301 (0.2234) | -0.0102 (0.1537) | 0.3052 (0.6151) | -0.0504 (0.3649) |
| Growth | 0.1893* (0.1042) | 0.1023 (0.1110) | 0.6180 (0.4376) | 0.3049 (0.2453) |
| Supplier-dominated (1/0) | -0.0148 (0.0300) | -0.1745*** (0.0308) | -0.1422 (0.1178) | -0.4448*** (0.0673) |
| Science-based (1/0) | 0.0988*** (0.0357) | -0.0378 (0.0361) | -0.0526 (0.1392) | -0.1424* (0.0763) |
| Scale-intensive (1/0) | -0.0638** (0.0268) | -0.1997*** (0.0276) | -0.5820*** (0.1073) | -0.4977*** (0.0603) |
| Germany (1/0) | -0.1383 (0.1555) | -0.0709 (0.1698) | -0.9487 (0.7767) | -0.1936 (0.3788) |
| Italy (1/0) | 0.0894*** (0.0311) | 0.0659** (0.0334) | 0.4097*** (0.1329) | 0.2013*** (0.0741) |
| Spain (1/0) | 0.0768*** (0.0301) | -0.0238 (0.0326) | 0.2177* (0.1309) | -0.0307 (0.0731) |
| Number of observations | 2781 | 2781 | 2152 | 2779 |
| Log-likelihood | -1641.91 | -1767.74 | -3510.11 | -3648.06 |
| Estimated probability | 0.6954 | 0.6415 | | |

Notes: Figures reported in the table are marginal effects for the sub-sample of small firms (up to 50 employees). Standard errors are in parentheses. Innovation is equal to 1 if a firm reports to have carried out any product and/or process innovation and 0 otherwise. R&D is equal to 1 if a firm reports to have undertaken any R&D activities and 0 otherwise. Innovation intensity is the logarithm of one plus the innovation intensity. R&D intensity is the logarithm of one plus the R&D intensity. Number of banks, size and age are in logarithm. Share of main bank, long-term leverage, short-term leverage, cash-flow, fixed assets and growth are the logarithm of one plus the specified variable. The (1/0) notation denotes dummy variables. Base category for Pavitt sectors is specialised suppliers. Base category for countries is France. *, **, *** denote respectively significant at 10%, 5% and 1%.