Relationship Lending and Firm Innovativeness: New Empirical Evidence

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Abstract

This study investigates the effects of relationship lending on firm innovativeness, disentangling the impact of bank ties on the discovery phase from that in the introduction phase of new technologies. Results suggest that for small firms, banks do not carry out a sophisticated intervention at the stage of development of new technologies playing their traditional role of financing investments of constrained firms. For low-tech firms, longer relationship with the main bank can have also negative effects on firm capacity to innovate. On the contrary, relationship banks do play an important role in both phases for high-tech firms.

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1 Introduction

As the fourth Community Innovation Survey highlighted, for the majority of Italian firms the main obstacle inhibiting innovation is represented by financial factors. Firm's financial need, however, is not constant and varies in relation to firm characteristics as well as project phases. For example, during the so-called *seed* phase, the financial need to carry out a feasibility study is rather low, whereas it is high in the *start-up* phase, when the project has to be implemented. During the *early growth* stage, instead, a firm requires considerable fundings in order to market its innovative products. Lacking the visibility of more established firms, young and small firms are likely to suffer even more for the financing of their investments because of asymmetric information problems (Berger and Udell (1998)). Moreover, the different phases of a project are characterized by different degree of risk.

Relying on a panel of Italian manufacturing firms, the main objective of the following empirical investigation is to examine the effects of relationship lending on firm innovativeness identifying two phases of the innovation process: the 'discovery phase', which captures firm financial needs related to the development of an innovation, and the 'introduction phase', which in the spirit of this paper depicts financial needs associated with bringing products to the market.

As Italy has strongly relied on relationship banking to finance investments, focusing on Italian firms allows to isolate the role of bank-firm relationship in fostering innovation. In particular, Italian banks seem better suited to financing innovation embodied in physical capital rather than R&D investment. As it is documented in Ughetto (2007), there is a striking difference in the share of bank loans as a source of funds for fixed capital compared with that one for R&D projects. In the same line, Herrera and Minetti (2007) suggest that relationship banks do not carry out a sophisticated intervention at the stage of assessment and development of new technologies and they rather play their traditional role in financing investments of otherwise financially constrained firms.

In order to disentangle the effects of bank ties on the discovery phase from those in the phase of introduction and adoption of new technologies, the following analysis proceed in two steps, first by measuring firm *propensity to innovate* in the discovery phase, and then by estimating firm *intensity* *to innovate* in the introduction phase, as measured by the percentage of new products in total sales. From the econometric perspective, it means to adopt a generalised tobit model which tries to account for the fact that firms are either innovative or not, and, for those that are innovative, the extent to which they are so (Mohnen et al. (2006)). This strategy has several advantages. Firstly, it allows to distinguish between different levers that banks can use to influence innovation, among which the provision of funds is of course the most important. Distinguishing between invention and introduction of new technologies is also important in the light of firm innovation patterns, as Italian firms tend to absorb innovations from outside than in carrying out research. Finally, it allows to control for selectivity problems. In recent years, a number of panel estimators have been suggested for sample selection model where both the selection equation and the equation of interest contain individual effects which are correlated with explanatory variables (Raymond et al. (2007), Dustmann and Rochina-Barrachina (2007)). In particular, I will rely on the estimator proposed by Rochina-Barrachina (1999) which extend Heckman's two step estimator deriving an expression for the selectivity correction term for two different time periods.

As the empirical determinants of relationship lending have been already investigated in the literature (i.e., Elsas (2005)), I will only give a recall of its key elements so as to focus on the reasons why bank ties should affect firm innovative capacity.

To get a complete picture, since the dataset also offers indications on the other type of financing, I will take into account other sources of finance available to the firms, as well as the role of public incentives. Since banks are by far the most important source of external finance in Italy, it is reasonable to expect the internal sources to play a crucial role in financing innovation.

Another important peculiarity of the Italian banking system is its delimitation in local areas, corresponding to 103 provinces which are geographical units close to US counties (Guiso et al. (2004, 2006); Colombo and Turati (2004)). The geographical segmentation is relevant in order to identify the level at which competition indicators, which are important control variables in the present analysis, have to be computed.

Closely related to this analysis are the works of Benfratello et al. (2007) and Herrera and Minetti (2007). However, it differentiates from them for various reasons. First of all, the more recent dataset used. This work will rely also on the latest Capitalia survey (the ninth). It also departs from Benfratello et al. (2007) for having a deeper look at the effects on innovation of specific bank-firm ties (such as the duration), distinguishing the discovery from the introduction phase, instead of focusing on the level of financial development. With respect to the work of Herrera and Minetti (2007), the methodology adopted is substantially different. These authors in fact investigated the possibility of endogeneity of the relationship variables while estimating the probability of introducing innovation. In this work, the method of estimation should account for this problem, considering in addition other important variables that in their work have been neglected. In particular, the effects of intensity of fixed capital and R&D Investment, as well as the role of internal source of financing in the probability of being innovative.

The paper is structured in the following way. The next section gives an overview of the literature while section 3, after a brief recall of the empirical determinants of relationship lending, explores its possible links with firm innovativeness. Section 4 presents the dataset and the main descriptive statistics on the degree of firm innovativeness. Section 5 presents the model, which distinguishes the introduction and discovery phases of innovation, and results for a cross-section of firms using data from the ninth Capitalia survey. On the contrary, section 6 and 7 presents a deeper analysis relying on panel data estimators for the discovery phase and introduction phase respectively. The final section summarizes the paper.

2 Literature Review

A lively macro-economic debate on the role of financial architecture in fostering innovation and technology is the one on the bank-based versus market-based system (i.e.,Carlin and Mayer (2003), Levine (2002)). Are bank-based systems at the advantage in processing information particularly relevant for firms' incentive to innovate? The available evidence is rather mixed but findings suggest that market-based system do not dominate bank-based system and vice-versa in all times. However, knowledge-intensive industries, with soft, hard-to-monitor complex activities seem to get on better in bank based financial systems (Tadesse (2007)).

Even though researchers have argued theoretically, and tested empirically, that there is a link between finance and innovation, there is still little in the existing micro-economic literature about the functions of the various sources of funding in the different phases of innovation (O' Sullivan (2004)). The main contribution of this paper is to make another step in this direction, enhancing our understanding of the role played by banks ties in the phases of invention and introduction of new technologies.

In fact, this paper relates to two, somehow separated, strands of empirical literature. The first comprehends articles on the economics of innovation. During the past decade, a number of countries in Europe have implemented enterprise-based surveys of innovative activity (i.e., Community Innovation Survey (CIS). At the same, important progress has been made in modelling appropriate econometric methods for innovation survey data (Raymond et al. (2007)). Hall and Mairasse (2006) provide an interesting review of the empirical studies on innovation.

The second strand mainly relates to works investigating bank-firm relationship. Since there is a vast literature on this topic, here I only refer to works related to the Italian banking system. For a review, see Elyasiani and Goldberg (2004) and Degryse and Ongena (2008). Some of these works investigate the credit access for firms belonging to industrial districts. Relying on the ninth Capitalia survey, Ughetto (2006) and Rotondi(2005) show that firms in industrial districts are less likely to be credit rationed. In particular, Alessandrini et al. (2008) evidence that the incidence of relationship lending for firms in industrial districts is not significantly different from the average. Ferri and Messori (2000) show that arm's length patterns prevail in the Northwest, the area of oldest industrialization with larger banks and firms, whereas relationship banking patterns prevail in the rest of the country, populated to a larger extent by smaller banks and firms.

Someways in-between, there are the works of Benfratello et al. (2007) and Herrera and Minetti (2007) which, instead, stress - at micro level - the role of bank of Italian banks in fostering innovation. Benfratello et al. (2007) find strong evidence that banking development has a significant and important impact effect on process innovation and a weaker for product innovation. In addition, they find that banking development has lessened the severity of financing constraints faced by small firms. Herrera and Minetti (2007) test the impact on innovation of the information of the main bank - proxied by the duration of credit relationship. They observe that firms with longer credit relationship have higher probability to innovate. Furthermore, the length of the relationship seems to foster the acquisition of new technologies rather than internal research. Using a large panel of US companies, Atanassov et al. (2007) explore the relationship between arm's length financing and innovation taking patents as a measure of innovative output. They found that firms that relied more on arm's length financing are associated with a larger number of patents. They also conclude that this correlation is mainly driven by innovative firms choosing their capital structure. Relying on firm-level data from a survey conducted in Finland, but looking instead at the role of public policy, the work of Hyytinen and Toivanen (2005) provides evidence that capital-market imperfections delay innovation, and government funding disproportionately helps firms in industries that are more dependent on external finance. They used as a measure of firm innovativeness the level of R&D expenditure.

3 Relationship lending and Firm innovativeness

In this section, in order to identify the main variables to be used in the empirical analysis, first, I will recall the key elements of relationship lending. Then, I will investigate the reasons why relationship lending should affect the phases of innovation. For a detailed description of the empirical determinants of relationship lending see Elsas (2005), whereas for an analytical survey on the effects of relationship lending on the pricing of loans, as well as its effect on the degree of competition, see Freixas (2005).

3.1 Empirical determinants of relationship lending

Relationship lending represents the informational privilege that a bank accumulates over time by establishing close ties with its borrower (Ongena and Smith (2001)). Reflecting the idea that long tenure depicts the relationship intensity, the most commonly proxy for relationship lending is the *duration* of a bank-borrower relationship. The exclusivity of bank relationship is also regarded as an indicator of close ties between the bank and the borrower. In this regards, the *number of bank relationships* should capture the possibility for bank to realize the economic benefit associated with the relationship. A negative correlation between the number of banks and the development of relationship lending is reasonable. Finally, a higher debt *financing share* should increase the likelihood of relationship lending.

Credit concentration has also been identified as an important determinant of bank-firm ties (Ongena et al. (2007)). Asymmetric or concentrated borrowing may in fact play a role in balancing the hold-up problem of relationship lending. Unfortunately, Capitalia survey does not provide such information.

3.2 Relationship lending and innovation

In Italy relationship lending has always been a way to channel funds to productive investments. In fact, despite its development, the stock market does not play a crucial role, while specialized financiers play a marginal role. In 2004, in the comparison between the Italian and the European venture capital industry - in term of venture capital and private equity instruments over GDP - Italy ranked 12th, with all other large European economies ranking well above. In addition, the Italian venture capital industry is focused on later-stage investments: on average, in 2004, early stage financing represented only 2% of total investments in Italy compared with 6.4% in Europe (Gregoriou et al. (2006)). Banks, in particular, turned out to be better suited to finance innovation embodied in physical capital rather than technological progress (Ughetto (2007)). As Italian firms typically do not receive external equity, internal equity finance (auto-financing/cashflow) represented an important source of innovation financing as well. Capitalia survey shows that, in 2001-2003, for 83% of firms auto-financing still represents the main source to finance innovation, followed by 10% of firms relying more on public incentives, and 5% on banks loans.

Different theoretical arguments point out that investment in R&D activities is different from investment in capital goods. First, R&D project may not be easily understood by outsiders and create large intangible assets which cannot be used as a collateral (Hall (2002)). In addition, expected returns of R&D are uncertain and difficult to estimate. Finally, as suggested by Bhattacharya and Chiesa (1995), firms may be reluctant to finance externally their R&D project for strategic reasons.

In which way then, relationship lending affects firm innovative capacity? Can it mitigate firm resort to internal finance? What makes a relationship lender special in fostering innovation?

The theoretical connections between innovation and relationship lending are diverse. First of all, it is important to notice that banks, in addition to have a direct effect on the quantity of R&D

and investment spending, may affect the nature of the selected project, the quality of internal inputs as well as their effectiveness in generating innovation. In fact, as Boot (2000) argued, relationship banking goes beyond lending and includes other services as well. In this regard, relationship lending leaves room for flexibility and discretion allowing the utilization of non-contractable information and addressing contractual features that are possibly unique. Furthermore, the firm can disclose information to the bank without worrying about it spilling over competitors. Finally, bank ability to offer multi-period contracts, which are much more effective than one-shot contracts (i.e. transactions) in extracting information, may be helpful in the allocation process and the mechanisms that allow firms to make commitments of resources to innovative activities, notwithstanding the challenges of doing so.

On the other hand, close and durable relationship may also involve inefficiencies, mainly related to the hold-up and soft-budget-constraint problems. The hold-up problem refers to the possibility that relationship bank may extract rents thus causing inefficient choice investment (see von Thadden (1995), and for a review Allen and Carletti (2008)), whereas the soft-budget-constraint problem concerns the bank's incentive to refinance some of the ex-post inefficient projects (Dewatripont and Roland (2000)).

As there are conflicting predictions, and the empirical research has lagged theoretical development, in the following empirical investigation it seems therefore crucial to account for firm heterogeneity (small vs large, and low-tech vs high-tech) in order to identify and differentiate the effects of relationship lending on firm capacity to innovate in relation to firm characteristics.

4 Data description

The data used in this work are obtained by the two most recent waves - the 8th and the 9th - of the comprehensive survey on Italian manufacturing firms carried out by Capitalia (and previously by Mediocredito Centrale) every three years[1]. These surveys are conducted through questionnaires, administered to a representative sample of manufacturing firms within the national borders. Questionnaires collected information over the previous three years (1998-2000 and 2001-2003) and, for

[1] See "Indagine sulle imprese manifatturiere" `http://www.capitalia.it/pages/studi02b.htm.`

the majority of the firms, are supplemented with standard balance sheet data. The 8th and the 9th survey include respectively 4289 and 4497 firms. To broaden the sample period of the analysis, I merged these two waves and obtained a reduced sample of 2097 firms. This sample includes only those firms existing in both surveys and therefore with potentially complete observations over the 1998-2003 period. I further excluded firms with incomplete information or with extreme values. I will progressively use the panel structure of the data in order to check and address the endogeneity problems: in the next section I will present result for a cross-section of firms surveyed in the ninth wave, whereas in the following sections I will rely on both surveys performing panel data estimations.

Based on this sample, tables (1) and (2) report the population percentages (and standard errors) of firms with either product or process innovation. The most important information is the increasing percentage of innovative firms, across size and sectors, over the period considered (the only exception is the % of firms with more than 500 employes doing process innovation). These higher percentages reflect the higher number of firms doing R&D. As table (3) shows, particularly in high-tech industries, the majority of firms are envolved in R&D activities. This is even more visible for larger firms where this percentage reached 92% in high-tech sectors[2]. Table (4) reports the (population) mean of the variables measuring relationship lending for the period 2001-2003. There are not significant differences in the duration of the relationship with the main bank, in the bank main share, and in the number of lending banks between small low-tech and high-tech firms, as well as for large low-tech and high-tech firms. There are significant differences when comparing these values according to the size variable. Interesting to note, however, is that there are no significant differences for small and large high-tech firms in the mean value of the variables related to the main bank (duration and share).

[2] According to NACE classification, firms where classified as in:

- low-tech sectors: textile, wood, food, plastic, paper, coke, non metallic and nec (not elsewhere classified).
- high-tech sectors: vehicles, machinery and chemicals

5 The empirical model and results

I adopt a generalized (Type 2) Tobit model consisting of two equations, where the first one is a probit equation determining whether a firm innovates or not ("propensity to innovate"), and the second one is a linear regression (the Tobit equation or "intensity to innovate") explaining how much the firm innovates (Mohnen et al. (2006)). I will measure firm innovative propensity by means of new processes and new products introduced into the market, whereas the firm innovation intensity can be measured by the share of innovative sales in total sales. Contrary to other type of surveys (i.e, Community Innovation Survey - CIS), it is not possible to distinguish between innovative sales corresponding to products new to the firm but possibly known to the market, which can be considered imitations of product already produced by other competitors, and those corresponding to products only new to the market, which can be regarded as true innovations.

Denoting by d_i the binary variable indicating if firm i is an innovating firm - that is, a dummy variable indicating whether the firm either has introduced at least one product or process innovation - I can write

$$d_i = \begin{cases} = 1 \quad if \quad d_i^* > 0 \\ = 0 \quad if \quad d_i^* \leq 0 \end{cases} \tag{1}$$

where $d_i^* = z_i b_1 + e_i$ is a latent variable that represents the incentives to innovate. z_i is a vector of explanatory variables, b_1 is a vector of parameter to be estimated, and e_i is a random error term, which includes the effect of left-out omitted variables. As explanatory variables z_i, in addition to the amount of resources spent on R&D per employee ($[IE]$) and fixed capital per employee($[INVEST]$), I use an industry dummy ($[HIGH\_TECH]$), firm size and age ($[SIZE]$, $[AGE]$), and a dummy for listed company ($[LISTED]$). The industry dummy ($HIGH\_TECH]$) captures technological opportunity conditions, industry-targeted innovation policies, and high-tech specific differential demand growth effect. Size - measured by the number of employees - reflects access to finance, scale economies and difference in the organization of work (Mohnen et al. (2006)). In order to account for the fact that young firms grow faster, I add a dummy for firms that are less than three years old ($[YOUNG]$). It is valuable to include a dummy also for firms that underwent structural change ([$M\&As$]) during the period of the analysis and for firms operating in international markets ([$INTERNATIONAL\ COMP$])[3].

As the main objective of my investigation is to control how relationship lending affect firm innovativeness, I estimate the probability to be innovative controlling for relationship lending including in the explanatory set, z_i, variables representing

- the share of the main bank on total banking debt: [$BANK\_SHARE$]
- the duration of the relationship: [$LENGTH$]
- the number of bank lenders: [NUM_BANKS]

Finally, to account for the possibility to have access to other sources of funding, I include in the regressors a dummy variable, [FIN_INSTR], for firms that relied on innovative financial instruments, such as financial bills or project finance. The second equation of the Tobit (type 2) model is specified in terms of a second latent variable s_i^* which is equal to the actual share of innovative sales y_i, if the firm is innovative (i.e, $d_i^* > 0$). Since the share of innovative sales is bounded by 0 and 1, it is preferable to perform a logit transformation of the data and express this second equation in terms of the latent logit-share variable $y_i^* = ln(s_i^*/(1 - s_i^*))$ which vary from $-\infty$ to $+\infty$. Thus I can write our second equation as

$$y_i = \begin{cases} = y_i^* & if \quad d_i^* > 0 \\ = undefined & if \quad d_i^* \leq 0 \end{cases} \tag{2}$$

or equivalently

$$s_i = \begin{cases} = e^{y_i^*}/(1 + e^{y_i^*}) & if \quad y_i^* > 0 \\ = 0 & if \quad y_i^* \leq 0 \end{cases} \tag{3}$$

where $y_i^* = x_i b_2 + u_i$.

x_i is a vector of explanatory variables, b_2 is a vector of parameters to be estimated and $u_i > 0$ is an error term reflecting omitted variables. Since I have data on sale growth for the majority of

[3] All the analysis were also performed replacing SIZE with its logarithm and including a dummy equal to 1 for firms included in a group. Results with the log of size do not change significantly, whereas the group dummy variable did not turn out to be significant.

the firms in the panel, I exploit the panel structure of the data in order to exclude the variable past sales growth ($[g\_sales_{[t-1]}]$) from the explanatory variables I have in x_i, and to include it in z_i. This variable in fact can be a determining factor of innovation, as reflecting stronger demand and easier internal and external access to finance. There are a lot of missing values in the variables of interest. For example, many firms do not indicate the amount of resources spent on R&D. The final sample is made of 1221 observations for the period 2001-2003. I also present some results using as exclusionary variable $[rationed_{[t-1]}]$, a dummy variable which is equal to 1 if the firm answered to be credit rationed in the previous survey. Results are substantially equals, even though this variable resulted more significant in some specifications. However, $g\_sales_{[t-1]}$ seems more reliable since it based on balance sheet data - instead of being determined by firm self assessment - and it offers indications on the role of internal sources [4].

Assuming that e and u are bivariate normal with zero mean, and $\sigma_e = 1$, I can estimate the model as a generalized Tobit (type 2) model using STATA Heckman procedure for survey analysis. Therefore, estimates will not refer to the sample but to the population of Italian firms. Preliminary results for the model without considering any financial variables are reported in table (5). Table (6) reports results for the basic model relying on $rationed_{[t-1]}$ instead of $g\_sales_{[t-1]}$ as exclusionary variable. Those preliminary results suggest the plausibility of the model, and the significance of the ρ coefficient indicates selection problems in the intensity innovation equation. Results for traditional regressors are in line with the literature. Firms with higher spending on R&D and fixed investments are those most likely to introduce an innovation. Larger and listed firms, especially in high-tech industries, are also more likely to be innovative and to have a higher percentage of sales stemming from innovative products. International agreements on production as well as public incentives also positively affect firm capacity to innovate.

In table (7) results for the model controlling for financial variables are reported. These results evidence that relationship variables do matter in explaining firm innovative capacity: the variables accounting for the share of the main bank and the number of lending banks are jointly highly

[4] More precisely, firms are defined to be credit rationed if answer yes to all the following question: *1.* whether at the current market interest rate they wish a larger amount of credit; *2.* whether they would be willing to accept a small increase in the interest rate charged in order to obtain more credit3. whether they have applied for credit but have been turned down by the financial intermediary.

significant, both in the intensity and propensity to innovate equation. However, theoretical and empirical works suggest that the market for SME finance is imperfect (see, for example, Alessandrini et al. (2007); Hyytinen and Toivanen (2005); Carpenter and Petersen (2002)): the opportunity cost of investments (the marginal cost of capital schedule) is higher for small firms (upward-sloping curve). That means, SMEs that are in need of (external) capital are more likely to pursue some innovations and positively affected by long-term relationship with some banks. To account for this possibility, and to control how it will affect the role of bank relationship in fostering innovation, table (7) also reports results for relationship variables interacted with a dummy variable for SMALL firms. At 1% level, a higher share of the major lending bank will have a positive effects on the capacity of small firms to translate innovation into a greater percentage of firm sales stemming from innovative products, and at 5% level it will have a positive effect on the probability of introducing an innovation. On the other hand, contrary to what have been found by Herrera and Minetti (2007), longer relationship may have counter positive effect on firm capacity to innovate. However, this result is not highly significant and the overall effect on both the capacity and intensity to innovate for small firms is not significant. These results are robust and reinforced if the exclusionary variable $[g\_sales[t-1]]$ is replaced by a dummy variable for firms being credit rationed in the previous survey (see table (8)).

5.1 Relationship Lending and Measure of Dependence on External Finance

Relying on the same set of variables used in the previous section, and by further exploiting the panel structure of the data, in this section I will estimate the previous model by identifying industries' *technological demand for external finance*. The reason for bringing into the picture this variable is related to the necessity to control for some specific industry features which may affect both the firm capacity to innovate and the role of bank ties.

In order to do that, following Hyytinen and Toivanen (2005) and differently from Benfratello et al. (2007), I will compute my own measure for external dependence for Italian manufacturing firms, amending the Rajan and Zingales (1998)'s methodology (RZ). The main assumption of RZ is that there are technological reasons why some industries rely more on external finance than others (i.e, gestation periods of products, the initial project scale, the cash harvest period). It seems important therefore to look how these 'intrinsic' industry features may affect bank ties, and ultimately firm capacity to innovate. It is reasonable to think that the effects of relationship lending variables should vary with the needs of external capital: the more firms are dependent on external finance, the stronger the ties with banks, and the higher the effects on firm innovativeness.

However, it would be risky to assume that industry demands for external financing in Italy will be the same of large listed US firms. Shifting the focus to between industry differences, therefore, I will a measure of external finance dependence using firm-level variables as collected during the eight Capitalia survey. As in Hyytinen and Toivanen (2005), I estimate the measure of external finance, using a financial planning model (called also the *percentage of sales* approach, see Demirgüç-Kunt and Maksimovic (2002)). This index, denoted by EFN, measures the proportion of firms whose annual growth rate of sales exceeds the maximum growth rate that can be financed if a firm relies only on its internal resources and maintain its dividend (see box 1). Those firms whose actual mean growth rates are above the maximum one are assumed to be in need of external finance.

The main advantage of computing this index is to (partially) control also for reverse causality. As pointed out by Herrera and Minetti (2007), measures such as the length of the relationship might be endogenous to the innovation process. The econometric specification chosen, already accounts for selectivity problem, as the significance level of ρ coefficient in the various specification indeed points out. Since the measure of external financial dependence is computed at industry level (NACE classifications), and using data on the eight survey, it is not affected by the current firm behaviour. The introduction of such a measure in interaction with relationship lending variables should therefore account for the possibility that firm with greater financial need will tend to have longer/strength ties with lending banks.

Box 1: **External Financial Need**

The percentage of sales model relates a firm growth rate to its need for external funds. The external financing need, EFN_t, at time t growing at g_t percent a year is given by

$$EFN_t = g_t Assets_t - (1 + g_t) Earnings_t * b_t$$

On the right hand side, the first term is the required investment for growing at g_t percent while the second term is the internally available capital for investment, taking b_t - the proportion of the firm earnings that are retained for reinvestment at time t - as given. Earnings are calculated after interest and taxes. I compute two estimates of each firm's attainable growth rate. The maximum growth rate that can be financed if a firm relies only on its internal resources and maintains its dividend, IG, is obtained by assuming that the firm retains all its earnings (that is $b_t = 1$), equating EFN_t to zero and solving for g_t

$$IG_t = ROA_t/(1 - ROA_t)$$

where ROA is the firm's return on assets. Thus, more profitable firms can find more resource internally. Then, I compare for each firm in the sample its actual growth rate with the rate, IG, defined above.

Finally, I compute for each industry (according to NACE classification) the proportion of firms in financial needs, that is those firms whose mean actual growth rate is above the mean maximum attainable. To check the robustness of the measure, I also compute the same percentage, assuming that firms does not pay dividend and obtain just enough debt financing to maintain a constant ratio of total debt to assets (implicitly also a summing that the firm does not issue equity or increase leverage). Again, setting EFN_t to zero, and using the value of equity in place of total assets, the growth rate is now equal to $SG = ROE/(1 - ROE)$. These measure are conservative in three ways. First, each maximum growth assumes that a firm utilizes the unconstrained sources of finance no more intensively that it is currently doing. Second, firms with spare capacity do not need to invest and may grow at a faster rate than predicted by the model. Third, the financial planning model abstract from technical advancement that reduce the requirements for investment capital. Thus it may overstate the cost of growth and underestimate the maximum growth rate attainable using unconstrained sources of finance (Demirgüç-Kunt and Maksimovic (2002, 1998)).

Results are reported in table (9) using the ROE version of the EFN index (see Box 1). In the first two column, the variable EFN is simply added to the basic model. In the last two column of table (9), EFN is introduced also in interaction with relationship lending variables. From that analysis three points deserve a remark. First of all, the coefficient on EFN is negative and significant in both equations, suggesting that firms that grow faster, and which are more in need of external finance, might find difficult to finance their innovation and bring new products to the market. This result is in line with CIS survey results which highlighted that for the majority of the Italian firms the main obstacles inhibiting innovation is still represented by financial factors. Secondly, even though the variables accounting for relationship lending turned out to be jointly significant, these regressions play down the importance of the share of the main banks (although still positive for firm with higher EFN). Finally, the length of the relationship and the number of lending banks are now significant - respectively at 6% and 10% level - in the propensity to innovate equation. In particular, they have a negative effect on the probability of introducing an innovation in those sector that are more in financial need. Even in this case, results are not affected if the exclusionary variable $[g\_sales[t-1]]$ is replaced by a dummy variable for firms being credit rationed in the previous survey.

To sum up, the analysis performed controlling also for financial need confirms the important role of the main bank in fostering innovation and suggest some possible counter positive effects when this relationship becomes longer.

5.2 Bank competition and Innovation

The level of competition among banks represents a factor which may either strengthen or weaken firm ties with the bank. On the one hand, there are theories that argue that competition and relationships are incompatible since banks may not enjoy the possibilities to extract profit later on in the relationship (Petersen and Rajan (1995)). On the other hand, other theories argue that more competition may instead increase relationship lending, allowing banks to mitigate the effects of fiercer competition extracting higher rents (Boot (2000); Boot and Thakor (2000)). Empirical works indeed suggest that competition and relationship lending are not necessary inimical (Degryse and Ongena (2007), Elsas (2005)).

In order to bring this element into the analysis, I will compute an index of banking competition at provincial level. The Italian territory is divided into 20 regions and 103 provinces, which are geographical units close to US counties. In accordance with the Italian Antitrust Authority, the presumption is that the province is the relevant market. More specifically, I will include in the regressors the number of bank branches per squared kilimoter $[BANK\_COMP]$ in each province. The branch density represents the monopolistic power of each branch and could be considered as a proxy of the (inverse of) transportation costs. More branches in the same provinces means, for each consumer, a lower distance to cover to reach a branch, a weaker power exerted by bank branch and an overall higher degree of competition (Degryse and Ongena (2005)).

$BANK\_COMP$ is a measure similar to the one propose by Benfratello et al. (2007), the number of branches per habitants[5]. In addition to that index, I also consider a traditional of

[5]This measure can be considered as a proxy for the (inverse of) queuing costs. The less the population served by each branch (or the higher the number of branches for each individual), the lower the cost met by the customers.

measure of market concentration, represented by sum of the market share of the first three banks [$CH3$]. Even in this case, I will focus on local markets by measuring market shares at the provincial level using data on branches as proxies for the market share of individual (or group of) banks. However, one must be cautious in interpreting this measure as a proxy of banking competition. As Claessens and Laeven (2004)' analysis shows, variables describing the banking system structure may not be good summary statistics for bank competitive environment. Conversely, these authors found that more concentrated banking system face a greater degree of competition. In this case, $BANK\_COMP$ and $CH3$ are negatively correlated (-0.41599).

Table (10) presents results adding the banking competition controls. For both those measures, there is a negative correlation with the firm innovativeness, in the introduction as well as in the discovery phase. However, $BANK\_COMP$ is not significant. The concentration index $CH3$ is instead jointly significant in the two equations at 10% level. This result suggests that less concentrated credit markets might foster innovation (Spagnolo (2004)). It is interesting to see how that variable interact with the external financial need. Results are reported in the last two column of table (10). The relationship is negative and significant both equations, however, it is not possible to reject the hypothesis that the overall effect in the discovery phase is zero. No significant interactions have been found between relationship lending variables and competition variables (not reported).

6 Relationship lending in the discovery phase

Relying on the same set of (time-varying) variables used in the previous section, and by completely exploiting the panel structure of the data, in this section I will focus on the effects of bank ties in the discovery phase only, in order to better control for endogeneity issues.

Given that I only have two observations about the introduction of innovation (in the eight and ninth survey), it is not possible to fully address the endogeneity problems and to identify causal links. However, since one fundamental problem is to control for unobserved firm characteristics that are constant over time, the conditional logit model will work properly. Conditional logit models eliminate the firm specific effects, but only switchers (that is, firms that introduced an innovation in just one of the two sub-periods) contribute to the likelihood function. Therefore, I can rely on a restricted number of observations, as only around 40% of the sample is made up of swicthers and not all the explanatory variables are observed for all firms in both periods. I cannot indeed control for another potential source of endogeneity caused by technological shock that leads, for example, to an increase both in the probability of observing an innovation and in the research intensity (Parisi et al. (2006)).

As in the previous analysis, relationship lending variables turned out to be significant in explaining the probability of introducing process or product innovations. In the model presented in table (11), they are jointly significant at 5% level. The most important result is again the role played by the share of the main bank. However, it is not possible to reject the hypothesis that the overall effect for small firms is equal to zero. Banks do seem not play a crucial role in the discovery phase for small firms. In the second column of table (11), I reestimate the model using a dummy variable for R&D, in $[IE]$'s stead, the variable measuring the amount of resource spent in R&D per employee, since there are firms that have reported to do R&D but were not able to indicate how much they spent for this purpose. In the same way, $[INVE]$ - replacing $[INVEST]$ - is a dummy variable equals to 1 if a firm declared that has invested in fixed capital but was not able to indicate the amount. Results are substantially identical.

In addition, in table (12), I repeat the same analysis but distinguishing the effects for high-tech and low-tech firms. Again, relationship variables are jointly significant at 5% level. At 10% level, it is also possible to reject the hypothesis that the variables representing bank ties are jointly equal to zero for high-tech firms. Looking at high-tech firms, then, it seems that bank might play a crucial role also in the introduction phase. In particular, for high-tech firms, also the length of the relationship turned out to be individually significant at 10% level. Those results are confirmed and reinforced in column (2). The baseline results from column(2) also suggest that longer relationship might have a negative effect for low-tech firms.

Tests of the conditional models confirm at 5% level the presence of fixed effects for small firms, whereas this hypothesis can be rejected for high-tech firms. For small firms, therefore, results from the conditional model are robust to correlation of regressors with firm fixed effects in contrast to the cross-section analysis. These results, however, are in line with the cross-section analysis, suggesting that banks do not play a crucial role in the discovery phase for small firms.

Overall, these regressions confirm the importance of bank ties in affecting firm innovative capacity, even though this is particularly true for firms in high tech sectors. Then, in line with the results of Herrera and Minetti (2007), it is possible to conclude that for small, banks do not carry out a sophisticated intervention at the stage of assessment and development of new technologies. For high-tech firms, instead, banks do play an important role in the discovery phase.

7 Relationship Lending in the introduction phase

In this section I will rely on a panel estimator in order to investigate the role of bank ties in the introduction phase by estimating a selection model where both the selection and regression equation may contain individual effects which are correlated with explanatory variables. In recent years a number of panel estimators have been suggested for these type of models (Dustmann and Rochina-Barrachina (2007), Raymond et al. (2007)). In particular, I will use the two step estimators approach proposed by Rochina-Barrachina (1999) which extend Heckman's sample selection technique developed in section 5 to the case where one correlated selection rule in two different time periods generated the sample. By nothing that for a firm which is innovative in two time periods - and therefore has been selected into the second stage estimation - this estimator eliminates the firm effects from the equation of interest (3) by taking time differences, and then condition upon the outcome of the selection process being "one" (observed) in the two periods (Rochina-Barrachina (1999)). This leads to two correction terms the form of which depends upon the assumption made about the selection process and the joint distribution of unobservables. With consistent estimates of these corrections terms, simple least squares can be used to obtain consistent estimates in the second step.

More precisely, the estimated equation is now given by,

$$\begin{aligned} y_{i2} - y_{i1} &= x_{i2} - x_{i1} + l_{12}\lambda_1(.) + l_{21}\lambda_2(.) + v_{i21} \\ \Delta y_{i21} &= \Delta x_{i21} + l_{12}\lambda_1(.) + l_{21}\lambda_2(.) + v_{i21} \end{aligned} \tag{4}$$

where the subscript refers to time 1 and 2, and λ_1 and λ_2 are the two corrections terms.

To construct estimates of the λ terms a bivariate probit of equation (1) is estimated in the first step for the two waves. Then, only for the subsample $d_2 = d_1 = 1$, I do a regression of Δy on Δx and $\hat{\lambda}$ to estimate the parameters of interest.

Results for the bivariate probit are not reported. However, estimations of the correlation coefficient turned out to be equal to 0.132 and significant at 5% level. Table (13) and (14) reports the second stage results for small firm and high-tech firms respectively where standard errors have been corrected in oder to take into account first stage estimation[6]. For high-tech firms variables representing relationship lending turned out to be positive and jointly significant at 10% level, suggesting that relationship banks do play a role for high-tech firms in the introduction phase as well. As the cross-section analysis in section 5 suggested, for small firms relationship banks play an important role in the introduction phase. In particular, this regression confirms the importance of the share of the main bank, which is again positive and significant. In addition, and also in line with the cross-section analysis, the competiton index turned out to be negative and significant at 5% level, suggesting that more concentrated banking market may not be favourable to innovation.

8 Conclusions

Using data on sample of Italian manufacturing firms, this study investigated the effects of relationship lending on firm innovativeness, disentangling the impact of bank ties on the discovery phase from that in the introduction phase and adoption of new technologies. As Schumpeter argued in his earliest writing on the microeconomics of innovation (Schumpeter (1934, 1939), O' Sullivan (2004)), banks are pivotal players in the innovation process and play a central role in real-sector innovation, not merely as a conduit for the movement of capital funds from savers to entrepreneurs. In Italy, in particular, relationship lending has always been a way to channel funds to productive investments, since both the stock market and specialized financiers have played a marginal role. However, despite the current richness of enterprise-based survey on innovative activity, there is

[6]For the asympotithic distribution and variance of this estimator see Rochina-Barrachina (1999) and Dustmann and Rochina-Barrachina (2007).

still little in the extant micro-economic literature about the different role of the various sources of funding in the introduction and invention of new technologies. On the contrary, at a macro-level, there is a lively debate on the role of financial architecture (bank-based versus market-based) in fostering innovation and technology.

Results from the present micro-econometric analysis suggest that for small firms, banks do not carry out a sophisticated intervention at the development stage of the innovation. Similarly to what found in other analysis, Italian banks appear to play their traditional role in financing investments of otherwise financially constrained firms. In addition,the econometric analysis suggest that small firms in more concentrated banking market are associated with a lower innovative capacity. Results also indicate that longer relationship with the main bank can have negative effects on firm capacity to innovate for low-tech firms. The length of the relationship also exhibits negative and significant effects on the probability of introducing an innovation in those sectors that are more in need of external finance. On the contrary, relationship banks turned out to play an important role in both the discovery and introduction phases for firms in high-tech sectors. In that case, a higher share and a longer relationship with the main lending bank have a positive impact on the capacity of high-tech firms to innovate.

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A APPENDIX I

In this section the variables used in the regressions are described. They are obtained from the 8th and 9th survey on Italian manufacturing firms carried out by Capitalia every three years.

INNOVATION: dummy variable which takes the value 1 if the enterprise reports having introduced new production processes or products during 2001

Pct_SALES: Share of turnover in 2003 due to new products or process introduced during 2001-2003.

IE:Average total expenditure for internal and external R&D divided per employees over the period 2001-2003.

R&D: dummy variable which takes the value 1 if the firm reports to have done R&D during the period 2001-2003.

INVEST: Average gross investments in innovative tangible goods per employees over the period 2001-2003.

INVE: dummy variable which takes the value 1 if the firm reports to have invested in innovative tangible during the period 2001-2003.

YOUNG: dummy equal to 1 if the firms is less then three years old

SMALL: dummy equal to 1 if the firms has less than 50 employees.

M&As: dummy variable which takes the value 1 if the firm's was involved in merger and acquisition dealings.

INTERNATIONAL_COMP: dummy variable which takes the value 1 if the enterprise's most significant market is international (outside EU).

INTERNATIONAL_AGREEMENTS: dummy variable which takes the value 1 if the enterprise has developed technical agreement with firms operating in international markets (outside EU).

PATENTS_BOUGHT: dummy which takes the value 1 if the firms bought patents during the period 2001-2003.

PATENTS_SOLD: dummy which takes the value 1 if the firms sold patents during the period

2001-2003.

PUBLIC_INCENTIVES: dummy which takes the value 1 if the firms relied on public incentives during the period 2001-2003.

LISTED: dummy which takes the value 1 if the firm is listed in the stock market

SIZE: average number of employees during the period. 2001-2003

BANK_SHARE: the share of the main bank in total banking debt

LENGTH:the duration of the relationship with the main bank

NUM_BANKS: the number of bank lenders

FIN._INSTR.: Dummy which takes the value 1 if the firm relied on innovative financial instruments during the period 2001-2003

BANK_COMP: number of branches per squared kilometer

CH3: market share of the first three banks

EFN: index of external financial dependence computed using firm-level variables as collected during the period 1998-2000

g_sales[t-1]: the turnover growth rate computed using variables as collected during the period 1998-2000

rationed[t-1]: dummy variable which takes the value 1 if the firm turned out be credit rationed during the period 1998-2000

Table 1: % of firms with a product innovation

FIRMS SIZE	LOW-TECH		HIGH-TECH	
(n° employees)	**1998-2000**	**2001-2003**	**1998-2000**	**2001-2003**
11-20	0.160 (0.014)	0.253 (0.027)	0.268 (0.017)	0.454 (0.034)
21-50	0.220 (0.015)	0.323 (0.032)	0.355 (0.016)	0.501 (0.027)
51-250	0.281 (0.030)	0.346 (0.039)	0.415 (0.015)	0.569 (0.022)
251-500	0.355 (0.064)	0.613 (0.076)	0.421 (0.046)	0.702 (0.050)
>500	0.598 (0.102)	0.671 (0.090)	0.391 (0.042)	0.426 (0.045)

() standard errors

Table 2: % of firms with a process innovation

FIRM SIZE	LOW-TECH		HIGH-TECH	
(n° employees)	**1998-2000**	**2001-2003**	**1998-2000**	**2001-2003**
11-20	0.287 (0.017)	0.321 (0.029)	0.287 (0.017)	0.297 (0.031)
21-50	0.364 (0.018)	0.397 (0.033)	0.371 (0.016)	0.417 (0.026)
51-250	0.490 (0.034)	0.497 (0.041)	0.494 (0.015)	0.508 (0.023)
251-500	0.460 (0.066)	0.660 (0.074)	0.498 (0.047)	0.614 (0.053)
>500	0.534 (0.102)	0.549 (0.099)	0.494 (0.043)	0.379 (0.044)

() standard errors

Table 3: % of firms doing R&D

FIRMS SIZE	LOW-TECH		HIGH-TECH	
(n° employees)	**1998-2000**	**2001-2003**	**1998-2000**	**2001-2003**
11-20	0.216 (0.016)	0.372 (0.030)	0.220 (0.016)	0.462 (0.034)
21-50	0.317 (0.017)	0.529 (0.034)	0.347 (0.016)	0.590 (0.026)
51-250	0.452 (0.034)	0.720 (0.037)	0.480(0.015)	0.704 (0.020)
251-500	0.632 (0.066)	0.879 (0.051)	0.561 (0.047)	0.783 (0.049)
>500	0.835 (0.079)	0.873 (0.069)	0.791 (0.044)	0.923 (0.031)

() standard errors

Table 4: Summary Statistics: Population Mean - Period 2001-2003

	BANK_SHARE	**LENGTH**	**NUM_BANKS**
LARGE & LOW_TECH	30.3299	20.0506	7.0150
	(1.451)	(0.819)	(0.235)
LARGE & HIGH_TECH	32.1561	18.0048	6.8789
	(2.009)	(1.013)	(0.260)
SMALL & LOW_TECH	35.3025	16.8680	4.1788
	(0.913)	(0.330)	(0.068)
SMALL & HIGH_TECH	34.0666	17.0709	4.1107
	(1.558)	(0.582)	(0.102)

Small firms: less than 50 employees

Table 5: Estimation results: HECKMAN BASE RESULTS

In the propensity equation the dependent variable is a dummy variable which takes value 1 if the firm has introduced at least one product or process innovation whereas in the intensity equation the dependent variable is a logit transformation of the actual share of innovative sales. The exclusionary variable is $g\_sales_{[t-1]}$

	Intensity		**Propensity**	
	Eq(2)		Eq(1)	
IE	0.2304***	(0.029)	0.1498***	(0.034)
INVEST	-0.0063	(0.011)	0.0107*	(0.006)
YOUNG	-2.7988***	(1.029)	-0.4416	(0.416)
AGE	-0.0067	(0.006)	0.0008	(0.003)
M&As	0.7726**	(0.342)	0.2562*	(0.149)
INTERNATIONAL_COMP	0.3367	(0.228)	0.1512	(0.104)
PATENTS_BOUGHT	0.1880	(0.586)	0.2385	(0.297)
PATENTS_SOLD	-2.0342**	(0.901)	-0.7128*	(0.382)
INTERNATIONAL_AGREEMENTS	0.4820	(0.335)	0.3210*	(0.168)
PUBLIC_INCENTIVES	0.6415***	(0.235)	0.3312***	(0.091)
LISTED	2.6064***	(0.932)	1.3997***	(0.379)
SIZE	0.0009	(0.001)	0.0020***	(0.001)
HIGH_TECH	0.2677	(0.252)	0.2019**	(0.098)
g_sales_{t-1}			0.2583	(0.165)
Constant	-9.4778***	(1.956)	-3.6785***	(0.765)
ρ	0.9110***	0.077		
σ	1.6903***	0.168		
ll	-34206.22			
N	564		1221	

*p<0.10,**p<0.05,***p<0.01

Note: Regressions include dummies for area

Table 6: Estimation results: HECKMAN BASE RESULTS

In the propensity equation the dependent variable is a dummy variable which takes value 1 if the firm has introduced at least one product or process innovation whereas in the intensity equation the dependent variable is a logit transformation of the actual share of innovative sales. The exclusionary variable is $rationed_{[t-1]}$

	Intesity		**Propensity**	
	Eq(2)		Eq(1)	
IE	0.2278***	(0.029)	0.1489***	(0.034)
INVEST	-0.0067	(0.011)	0.0117*	(0.006)
YOUNG	-2.7541***	(1.019)	-0.4107	(0.421)
AGE	-0.0079	(0.006)	0.0000	(0.003)
M&As	0.7027**	(0.338)	0.2399	(0.151)
INTERNATIONAL_COMP	0.3031	(0.228)	0.1474	(0.107)
PATENTS_BOUGHT	0.1340	(0.590)	0.2215	(0.307)
PATENTS_SOLD	-1.9874**	(0.862)	-0.6128*	(0.364)
INTERNATIONAL_AGREEMENTS	0.4512	(0.331)	0.3059*	(0.170)
PUBLIC_INCENTIVES	0.5929**	(0.238)	0.3152***	(0.093)
LISTED	2.7448***	(0.851)	1.2501***	(0.368)
LOGSIZE	0.2214*	(0.123)	0.2295***	(0.060)
HIGH_TECH	0.2445	(0.253)	0.1907*	(0.099)
rationed$_{t-1}$			0.3390*	(0.187)
Constant	-10.2786***	(1.964)	-3.9891***	(0.798)
ρ	0.9007***	(0.079)		
σ	1.6423***	0.177		
ll	-34136.07			
N	564		1221	

*p<0.10,**p<0.05,***p<0.01

Note: Regressions include dummies for area

Table 7: Estimation results: HECKMAN ADDING FINANCIAL VARIABLES

	Intensity	**Propensity**	**Intensity**	**Propensity**
	Eq(2)	Eq(1)	Eq(2)	Eq(1)
IE	0.2346***	0.1450***	0.2352***	0.1456***
	(0.031)	(0.032)	(0.032)	(0.032)
INVEST	-0.0082	0.0107*	-0.0083	0.0108*
	(0.011)	(0.006)	(0.011)	(0.006)
YOUNG	-2.9653***	-0.4748	-2.8975***	-0.4573
	(1.039)	(0.415)	(1.035)	(0.413)
AGE	-0.0060	0.0003	-0.0057	0.0004
	(0.006)	(0.003)	(0.006)	(0.003)
M&As	0.7040**	0.2207	0.6994**	0.2279
	(0.353)	(0.154)	(0.353)	(0.154)
INTERNATIONAL_COMP	0.3402	0.1434	0.3389	0.1468
	(0.234)	(0.102)	(0.234)	(0.103)
PATENTS_BOUGHT	0.1258	0.1910	0.2155	0.2047
	(0.572)	(0.285)	(0.551)	(0.280)
PATENTS_SOLD	-1.8987**	-0.7550**	-2.0047**	-0.6967**
	(0.819)	(0.362)	(0.870)	(0.355)
INTERNATIONAL_AGREEMENTS	0.4295	0.2907*	0.4404	0.2815*
	(0.353)	(0.165)	(0.350)	(0.164)
PUBLIC_INCENTIVES	0.6567***	0.3004***	0.6488***	0.2980***
	(0.239)	(0.091)	(0.240)	(0.091)
LISTED	2.6249***	1.5992***	2.7733***	1.5593***
	(0.919)	(0.367)	(0.817)	(0.356)
SIZE	0.0007	0.0014***	0.0000	0.0016**
	(0.001)	(0.001)	(0.000)	(0.001)
BANK_SHARE	0.0096**	0.0030*	-0.0020	-0.0008
	(0.004)	(0.002)	(0.006)	(0.003)
NUM_BANKS	0.0755**	0.0372**	0.0697*	0.0398**
	(0.035)	(0.016)	(0.037)	(0.016)
LENGHT	-0.0110	0.0007	0.0191	0.0054
	(0.012)	(0.005)	(0.013)	(0.006)
FINANCIAL_INSTR	-0.4494	0.3439	1.2566*	0.5794*
	(0.537)	(0.240)	(0.726)	(0.321)
HIGH_TECH	0.2568	0.2199**	0.2656	0.2231**
	(0.256)	(0.098)	(0.258)	(0.098)
NUM_BANKSxSMALL			-0.0073	-0.0061
			(0.047)	(0.020)
BANK_SHARExSMALL			0.0125*	0.0040
			(0.007)	(0.003)
LENGHTxSMALL			-0.0361**	-0.0059
			(0.016)	(0.007)
FINANCIAL_INSTRxSMALL			-2.0090**	-0.2981
			(0.975)	(0.414)
g_sales_{t-1}		0.2905*		0.2957*
		(0.152)		(0.152)
Constant	-10.1390***	-4.3320***	-10.3343***	-4.2368***
	(1.957)	(0.755)	(1.774)	(0.742)
ρ	0.9350***	(0.076)	0.9320***	(0.076)
σ	1.8696***	(0.177)	1.8796***	(0.175)
ll	-34206.22		-33901.71	
N	564	1221	564	1221

Table 8: Estimation results: HECKMAN ADDING FINANCIAL VARIABLES

	Intensity Eq(2)	**Propensity** Eq(1)	**Intensity** Eq(2)	**Propensity** Eq(1)
IE	0.2334***	0.1448***	0.2343***	0.1453***
	(0.031)	(0.033)	(0.032)	(0.033)
INVEST	-0.0088	0.0117*	-0.0088	0.0119*
	(0.011)	(0.006)	(0.011)	(0.006)
YOUNG	-2.8194***	-0.4563	-2.7508***	-0.4389
	(1.040)	(0.417)	(1.034)	(0.415)
AGE	-0.0063	0.0002	-0.0060	0.0002
	(0.006)	(0.003)	(0.006)	(0.003)
M&As	0.6974**	0.2246	0.6935**	0.2323
	(0.351)	(0.153)	(0.351)	(0.153)
INTERNATIONAL_COMP	0.3144	0.1571	0.3135	0.1608
	(0.235)	(0.105)	(0.236)	(0.105)
PATENTS_BOUGHT	0.1157	0.2177	0.2069	0.2316
	(0.567)	(0.288)	(0.545)	(0.283)
PATENTS_SOLD	-1.8683**	-0.7164**	-1.9560**	-0.6767*
	(0.801)	(0.364)	(0.842)	(0.356)
INTERNATIONAL_AGREEMENTS	0.4207	0.2851*	0.4329	0.2747
	(0.353)	(0.168)	(0.350)	(0.167)
PUBLIC_INCENTIVES	0.6444***	0.3072***	0.6363***	0.3053***
	(0.239)	(0.091)	(0.240)	(0.092)
LISTED	2.5990***	1.6244***	2.7276***	1.6237***
	(0.917)	(0.367)	(0.811)	(0.357)
SIZE	0.0007	0.0016***	0.0000	0.0018**
	(0.001)	(0.001)	(0.000)	(0.001)
BANK_SHARE	0.0095**	0.0030*	-0.0022	-0.0010
	(0.004)	(0.002)	(0.006)	(0.003)
NUM_BANKS	0.0727**	0.0390**	0.0670*	0.0403**
	(0.035)	(0.016)	(0.037)	(0.017)
LENGTH	-0.0100	0.0003	0.0197	0.0050
	(0.012)	(0.005)	(0.013)	(0.006)
FINANCIAL_INSTR	-0.4546	0.3339	1.2181*	0.5497*
	(0.543)	(0.249)	(0.729)	(0.330)
HIGH_TECH	0.2514	0.2158**	0.2610	0.2188**
	(0.255)	(0.098)	(0.257)	(0.099)
NUM_BANKSxSMALL			-0.0077	-0.0042
			(0.047)	(0.020)
BANK_SHARExSMALL			0.0126*	0.0042
			(0.007)	(0.003)
LENGTHxSMALL			-0.0357**	-0.0059
			(0.016)	(0.007)
FINANCIAL_INSTRxSMALL			-1.9774**	-0.2736
			(0.982)	(0.425)
past_razion		0.2981*		0.3083*
		(0.165)		(0.163)
Constant	-10.0185***	-4.3766***	-10.1754***	-4.3645***
	(1.958)	(0.756)	(1.764)	(0.745)
ρ	0.9265***	(0.077)	0.9242***	(0.077)
σ	1.8187***	(0.181)	1.8317***	(0.177)
ll	-33989.84		-33920.19	
N	564	1223	564	1223

Table 9: Estimation results: HECKMAN CONSIDERING EXTERNAL FINANCIAL NEED

	Intensity Eq(2)	**Propensity** Eq(1)	**Intensity** Eq(2)	**Propensity** Eq(1)
IE	0.2313***	0.1455***	0.2320***	0.1484***
	(0.031)	(0.032)	(0.032)	(0.033)
INVEST	-0.0043	0.0122*	-0.0030	0.0148**
	(0.011)	(0.006)	(0.012)	(0.006)
YOUNG	-2.8809***	-0.4646	-2.8493***	-0.4987
	(1.045)	(0.414)	(1.045)	(0.419)
AGE	-0.0039	0.0008	-0.0039	0.0005
	(0.006)	(0.003)	(0.006)	(0.003)
M&As	0.7492**	0.2249	0.7900**	0.2233
	(0.344)	(0.152)	(0.342)	(0.147)
INTERNATIONAL_COMP	0.3105	0.1379	0.2966	0.1351
	(0.235)	(0.103)	(0.234)	(0.104)
PATENTS_BOUGHT	0.0842	0.1535	0.0284	0.1790
	(0.548)	(0.286)	(0.548)	(0.295)
PATENTS_SOLD	-1.8732**	-0.7391**	-1.8391**	-0.7275**
	(0.798)	(0.357)	(0.805)	(0.363)
INTERNATIONAL_AGREEMENTS	0.4183	0.2912*	0.4313	0.2815*
	(0.357)	(0.166)	(0.353)	(0.163)
PUBLIC_INCENTIVES	0.6317***	0.2923***	0.6235***	0.2922***
	(0.235)	(0.091)	(0.234)	(0.091)
LISTED	2.3161**	1.5363***	2.2356**	1.4683***
	(0.913)	(0.366)	(0.889)	(0.379)
SIZE	0.0006	0.0014***	0.0005	0.0014***
	(0.001)	(0.001)	(0.001)	(0.001)
EFN	-4.9329**	-1.3892*	-0.6898	2.5253
	(1.922)	(0.793)	(4.668)	(2.055)
BANK_SHARE	0.0098**	0.0030*	0.0025	-0.0040
	(0.004)	(0.002)	(0.029)	(0.013)
NUM_BANKS	0.0766**	0.0391**	0.3077	0.2915**
	(0.035)	(0.016)	(0.231)	(0.119)
LENGHT	-0.0118	0.0006	0.0649	0.0629*
	(0.012)	(0.005)	(0.091)	(0.033)
FINANCIAL_INSTR	-0.3519	0.3861	-0.3020	0.4038*
	(0.534)	(0.242)	(0.530)	(0.238)
HIGH_TECH	-0.0099	0.1466	-0.0225	0.1597
	(0.267)	(0.106)	(0.266)	(0.106)
NUM_BANKSxEFN			-0.4692	-0.4966**
			(0.451)	(0.233)
BANK_SHARExEFN			0.0150	0.0143
			(0.058)	(0.026)
LENGHTxEFN			-0.1534	-0.1233*
			(0.177)	(0.065)
g_sales$_{t-1}$		0.2923*		0.2964*
		(0.152)		(0.152)
Constant	-7.0750***	-3.5296***	-9.0154***	-5.3868***
	(2.218)	(0.869)	(3.053)	(1.261)
ρ	0.9265***	(0.076)	0.9241***	(0.075)
σ	1.8518***	(0.177)	1.8588***	(0.169)
ll	-33905.42		-33805.31	
N	564	1221	564	1221

*p<0.10,** p<0.05,*** p<0.01

Note: Regressions include dummies for area

Table 10: Estimation results: HECKMAN CONSIDERING BANK COMPETITION

	Eq(2)	Eq(1)	Eq(2)	Eq(1)	Eq(2)	Eq(1)
IE	0.2367***	0.1458***	0.2366***	0.1464***	0.2306***	0.1466***
	(0.031)	(0.032)	(0.031)	(0.032)	(0.031)	(0.033)
INVEST	-0.0753	0.1061*	-0.0620	0.1048*	-0.0078	0.1304**
	(0.112)	(0.063)	(0.108)	(0.061)	(0.110)	(0.062)
YOUNG	-3.0125***	-0.4661	-2.9572***	-0.4729	-2.8982***	-0.4755
	(1.042)	(0.414)	(1.036)	(0.414)	(1.047)	(0.420)
AGE	-0.0059	0.0003	-0.0061	0.0002	-0.0038	0.0007
	(0.006)	(0.003)	(0.006)	(0.003)	(0.006)	(0.003)
SIZE	0.0008	0.0014***	0.0008	0.0014***	0.0006	0.0014***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
M&As	0.6941*	0.2230	0.6956*	0.2428	0.7613**	0.2573*
	(0.355)	(0.154)	(0.357)	(0.156)	(0.349)	(0.156)
INTERN._COMP	0.3426	0.1479	0.3316	0.1519	0.3139	0.1508
	(0.234)	(0.102)	(0.235)	(0.103)	(0.235)	(0.104)
PAT._BOUGHT	0.0876	0.1862	0.1431	0.2184	0.1212	0.2024
	(0.572)	(0.285)	(0.581)	(0.290)	(0.555)	(0.294)
PAT._SOLD	-1.9139**	-0.7566**	-1.8785**	-0.7575**	-1.9030**	-0.7708**
	(0.811)	(0.360)	(0.832)	(0.361)	(0.818)	(0.362)
INTERN_AGR.	0.4165	0.2952*	0.4113	0.2932*	0.3817	0.2778
	(0.356)	(0.166)	(0.356)	(0.171)	(0.363)	(0.170)
PUBLIC_INC.	0.6339***	0.2987***	0.6655***	0.3121***	0.6202***	0.2935***
	(0.241)	(0.092)	(0.242)	(0.092)	(0.239)	(0.092)
LISTED	2.6367***	1.6052***	2.6295***	1.6521***	2.3673***	1.6274***
	(0.897)	(0.362)	(0.934)	(0.376)	(0.915)	(0.377)
BANK_SHARE	0.0093**	0.0030*	0.0096**	0.0031**	0.0096**	0.0030*
	(0.004)	(0.002)	(0.004)	(0.002)	(0.004)	(0.002)
NUM_BANKS	0.0729**	0.0370**	0.0765**	0.0381**	0.0755**	0.0392**
	(0.035)	(0.016)	(0.035)	(0.016)	(0.035)	(0.016)
LENGHT	-0.0111	0.0008	-0.0114	0.0012	-0.0113	0.0013
	(0.012)	(0.005)	(0.012)	(0.005)	(0.012)	(0.005)
FINAN._INSTR	-0.4704	0.3438	-0.4733	0.3551	-0.4365	0.3745
	(0.535)	(0.240)	(0.538)	(0.239)	(0.525)	(0.240)
HIGH_TECH	0.2546	0.2217**	0.2493	0.2190**	0.0051	0.1550
	(0.256)	(0.098)	(0.257)	(0.098)	(0.267)	(0.106)
INDEX_COMP	-29.0333	-0.7384				
	(42.358)	(17.718)				
CH3			-0.2952	-0.7331	14.9524	7.3773**
			(1.229)	(0.499)	(9.353)	(3.556)
EFN					11.4127	7.1867*
					(9.914)	(3.735)
CH3xEFN					-29.9252*	-15.7572**
					(18.115)	(6.821)
g_sales$_{[t-1]}$		0.2754*		0.2433*		0.2672*
		(0.152)		(0.143)		(0.147)
Constant	-10.0364***	-4.3447***	-10.0199***	-4.0706***	-15.3394***	-7.7401***
	(1.926)	(0.750)	(2.078)	(0.800)	(5.635)	(2.120)
ρ	0.9355***	(0.076)	0.9388***	(0.076)	0.9260***	(0.076)
σ	1.87641***	(0.176)	1.9075***	(0.178)	1.832***	(0.181)
ll	-33960.81		-33922.26		-33806.81	
N	564	1221	564	1221	564	1221

*p<0.10,**p<0.05,***p<0.01

Note: Regressions include dummies for area

Table 11: Estimation results: **Conditional logit for small firms**
In this model only switchers - that is, firms that introduced an innovation in just one of the two periods - contribute to the likelihood function. It controls for unobserved firm characteristics that are constant over time. The dependent variable is a dummy variable equal to 1 if the firm introduced an innovation in just one of the two periods

	(1)	(2)
IE	0.1482	
	(0.126)	
INVEST	-0.0067	
	(0.006)	
RS		1.3156***
		(0.246)
INVE		1.5329***
		(0.338)
BANK_SHARE	0.0472**	0.0164
	(0.018)	(0.013)
NUM_BANKS	0.0693	0.0616
	(0.097)	(0.111)
LENGHT	-0.0147	-0.0134
	(0.015)	(0.017)
FINANCIAL_INSTR	1.9148**	1.5368**
	(0.913)	(0.598)
AGE	0.2276	0.5265***
	(0.167)	(0.164)
SIZE	0.0009	-0.0075
	(0.008)	(0.008)
M&As	0.9774***	0.6557*
	(0.362)	(0.383)
INTERN._COMP	0.4472	0.1539
	(0.390)	(0.319)
PATENTS_BOUGHT	0.8420	0.8919
	(1.203)	(0.866)
PATENTS_SOLD	-2.1721*	-0.1794
	(1.159)	(1.165)
INTERNATIONAL_AGREEMENTS	1.2011*	1.3871**
	(0.639)	(0.567)
CH3	1.0227	1.6642
	(4.754)	(4.650)
NUM_BANKSxSMALL	0.0525	0.0200
	(0.099)	(0.111)
BANK_SHARExSMALL	-0.0476***	-0.0221*
	(0.018)	(0.013)
LENGHTxSMALL	0.0137	-0.0027
	(0.018)	(0.019)
FINANCIAL_INSTRxSMALL	-1.2445	-0.6435
	(1.060)	(0.814)
ll	-4506.18	-5635.12
N	644	868

*p<0.10,** p<0.05, ***p<0.01

Table 12: Estimation results: **Conditional logit for high-tech firms**
In this model only switchers - that is, firms that introduced an innovation in just one of the two periods - contribute to the likelihood function. It controls for unobserved firm characteristics that are constant over time. The dependent variable is a dummy variable equal to 1 if the firm introduced an innovation in just one of the two periods

	(1)	(2)
IE	0.1575	
	(0.141)	
INVEST	-0.0068	
	(0.006)	
RS		1.2724***
		(0.241)
INVE		1.5405***
		(0.346)
BANK_SHARE	-0.0024	-0.0113**
	(0.006)	(0.005)
NUM_BANKS	0.1135	0.1103
	(0.088)	(0.099)
LENGHT	-0.0057	-0.0206*
	(0.011)	(0.012)
FINANCIAL_INSTR	0.9304	1.0857**
	(0.570)	(0.538)
AGE	0.2177	0.5496***
	(0.165)	(0.165)
SIZE	0.0055	-0.0003
	(0.007)	(0.008)
M&As	0.9453***	0.6716*
	(0.353)	(0.389)
INTERN._COMP	0.4691	0.1781
	(0.383)	(0.314)
PATENTS_BOUGHT	0.9256	0.6665
	(1.166)	(0.973)
PATENTS_SOLD	-1.4503	-0.2689
	(1.553)	(1.106)
INTERN._AGREEM	1.3334**	1.4723**
	(0.627)	(0.591)
CH3	0.9832	2.7103
	(4.712)	(4.702)
NUM_BANKSxHT	0.0851	-0.1732
	(0.200)	(0.183)
BANK_SHARExHT	0.0108	0.0228**
	(0.013)	(0.009)
LENGHTxHT	0.0228	0.0250
	(0.024)	(0.025)
FINANCIAL_INSTRxHT	-0.7965	-1.1040
	(1.431)	(1.721)
ll	-454.66	-5563.49
N	644	868

*p<0.10,** p<0.05,*** p<0.01

Table 13: **Heckman panel estimator for small firms (Rochina 1999)**
Two-stage panel estimation. The first step (not reported), is a bivariate probit using all the observation to estimate λ_1 and λ_2. In the second step, for the subsample of firms that innovate in both period, that is with $d_1 = 1$ and $d_2 = 1$, I do least squares of Δy on Δx,λ_1 and λ_2.

$\Delta INVEST$	0.3478***
	(0.002)
ΔIE	-0.0048
	(0.060)
$\Delta BANKSHARE$	0.0067***
	(0.003)
$\Delta LENGHT$	0.0234
	(0.019)
$\Delta NUMBANKS$	0.0489
	(0.130)
$\Delta SIZE$	-0.0195***
	(0.004)
$\Delta PATENT\_BOUGHT$	1.0835***
	(0.123)
$\Delta INCENTIVES$	-0.2245
	(0.287)
ΔFIN_INSTR	1.3811***
	(0.759)
$\Delta M\&As$	-0.6469**
	(5.277)
$\Delta CH3$	-12.4702**
	(7.039)
ΔAGE	-1.6164***
	(0.318)
lambda2	0.7392*
	(0.475)
lambda1	0.8507
	(0.843)
N	64

*p<0.10,** p<0.05, ***p<0.01

Table 14: **Heckman panel estimator for high-tech firms (Rochina 1999)**

Two-stage panel estimation. The first step (not reported), is a bivariate probit using all the observation to estimate λ_1 and λ_2. In the second step, for the subsample of firms that innovate in both period, that is with $d_1 = 1$ and $d_2 = 1$, I do least squares of Δy on Δx,λ_1 and λ_2.

$INVEST$	0.3476***
	(0.001)
ΔIE	-0.0679
	(0.284)
$\Delta BANKSHARE$	0.0126
	(0.024)
$\Delta LENGHT$	0.0392
	(0.083)
$\Delta NUMBANKS$	0.1674
	(0.884)
$\Delta SIZE$	-0.0045*
	(0.003)
$\Delta PATENT\_BOUGHT$	0.9969***
	(0.064)
$\Delta INCENTIVES$	-0.1260
	(0.743)
$\Delta PATENTS\_SOLD$	0.4620
	(4.808)
ΔFIN_INSTR	2.1110**
	(1.078)
$\Delta M\&As$	-0.3255
	(16.378)
$\Delta COMP$	-5.5178
	(5.798)
ΔAGE	-1.458
	(1.701)
lambda2	1.9641
	(0.339)
lambda1	0.5501
	(0.151)
ll	
N	67

*p<0.10,** p<0.05, ***p<0.01