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Abstract

Using direct information on financial constraints from questionnaires, rather than the commonly used balance sheet information, this paper presents evidence that, controlling for traditional factors as size, market share, cooperative arrangement, and expected profitability, financial constraints affect a firm's decision of how much to invest in R&D activities. Apart from these constraints, other hampering factors as market uncertainty and institutional bottlenecks, regulations and organizational rigidities also affect R&D investment. A semiparametric estimator of sample selection is employed to control for potential endogeneity of the regressors. The paper also shows that old firms and firms that belong to a group are less financially constrained when it comes to undertaking R&D activities. For the estimation a semiparametric binary choice model is used.

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1 Introduction

The connection between finance and investment starts with any violation of the Modigliani- Miller theorem, Modigliani and Miller (1958), usually modeled formally via imperfect information. According to Ross, Westerfield and Jordan (1993) about 80 percent of all financing is done with internally generated funds. Explanations for this behavior usually highlight the role of information asymmetries (Myers and Majluf, 1984) and agency issues (Jensen and Meckling, 1976) in raising the costs of external funds.

The notion of financial constraint that is employed in this paper is that of credit rationing which arises due to informational asymmetry between the borrower/firm and the lender about the quality of project that a firm wishes to undertake and also due to the risk of bankruptcy in the event of the failure of the project. Gale and Hellwig (1985) compare optimal contracts with the first best situation. First best situations are those that arise when borrowers and lenders share the same information about the nature and the outcome of the project, that is, there are situations where there is no informational asymmetry. An optimal contract is incentive compatible, which allows borrowers to truthfully reveal (since the firm has more information about the project than the lender) the outcome of the project and also takes into consideration that borrowers in their optimization program account for the possibility of bankruptcy and the costs associated with it. Gale and Hellwig (1985) also show that standard debt contracts that require a fixed repayment when the firm is solvent and that require the firm to be declared bankrupt if this fixed payment cannot be met and the creditor is allowed to recoup as much of the debt as possible from the firm's assets, are also optimal. In equilibrium, a standard debt contract, which is also optimal, will usually involve credit-rationing in the sense that the optimal loan is smaller and interest rate is higher than it would have been under the first best outcome.

Empirically, the existence of financial constraints for innovative firms is most frequently investigated by examining the sensitivity of R&D investment to financial factors, see Himmelberg and Petersen (1994), Harhoff (1998), and Mulkay, Hall and Mairesse (2001). It is estimated by using the same models as for physical investment, see Mulkay et al. (1999), that is to say, by using the reduced form of accelerator models of investment, see Fazzari, Hubbard and Peterson (1988) and Bond, Elston, Mairesse and Mulkay (1997), or by using the structural framework of Euler equations as in Bond and Meghir (1994). Himmelberg and Petersen (1994) find a large and significant relationship between R&D and internal finance for US small firms in high-tech industries. Similar results are obtained by Mulkay et al. (2001) with French and United States firms. In addition, they find that cash flow has a much larger impact on R&D investment for US firms than for the French ones. Harhoff's results about German firms are less conclusive. He finds a weak but significant cash flow effect on R&D by using an investment accelerator model, while Euler-equation estimates appear to be non-informative. However, Kaplan and Zingales (1997, 2000) and Cleary (1999) have provided evidence that cash flow sensitivity need not identify liquidity constrained firms, that is, sensitivity is not monotonic in the degree of constraints. Cash flow provides information about future investment opportunities, hence, investment cash flow sensitivity may equally occur because firms are sensitive to demand signals. On the theoretical side, Gomes (2001) and Aydogan (2003) simulate dynamic investment models, demonstrating that significant cash flow coefficients are not necessarily generated by financing frictions. Conversely, Gomes (2001) shows that financing frictions are not sufficient to generate significant coefficients on cash flow.

Among the many ways to study the effect of financing frictions on physical/R&D investment, one is to construct an index of financial constraints based on a standard intertemporal investment model augmented to account for financial frictions. External finance constraints affect the intertemporal substitution of investment today for investment tomorrow, via the shadow value of scarce external funds. Recently Gomes, Yaron, and Zhang (2006) showed that one can rewrite a constrained problem as an unconstrained one with embedded multipliers that give a characterization of the shadow value, as a measure of the premium on external finance. This shadow value, in turn, depends on observable financial variables and proxies that signal the worthiness of firms, as debt, equity, liquidity, cash flow, and bond ratings to name a few. Generalized method of moments estimation of the model provides an estimate of the shadow value that is then used as an index of financial constraint. Many papers in the literature on financing frictions use this approach to study the effect of financing premium on behavior of such variables as investment, see Whited (1992) and Bond and Meghir (1994), stock return, see Gomes et al. (2006) and Whited and Wu (2006), and the term structure of interest rates, see Dow, Gorton and Krishnamurthy (2004).

However, in our data set, which we obtain from the Community Innovation Survey (CIS), we do not have information on balance sheets of the firms/enterprises[i] , which would allow us to assess the effect of internal/external finance on the behavior of R&D investment. But, from a question asked to the firms we know whether a firm, and to what degree, was hampered in its pursuit of R&D activities by the presence of financial constraints. This avoids the task of constructing an index of financial constraint to study the behavior of R&D investment in the presence of capital market frictions. That is, we have an index of financial constraint that is a function of the financial position of the firm and its willingness to undertake R&D activities. The above statement needs some explanation. A constructed index of financial constraint is only a function of the financial state variable and this index is purged of the effects of future expected profitability. However, this is not the case for firms reporting whether they are financially constrained or not in our data set. In other words, the firms reporting that they are financially constrained are also the ones that express a willingness to invest in R&D activities, but their financial position is not sound enough for them to take up R&D activities. That is, if two firms are equal in every respect but one firm is in a better financial position than the other, then the firm that is in a better financial position is less likely to hit its debt limit than the firm whose financial position is not sound. Ceteris paribus, the worse the financial position of the firm, the greater is the loan demanded, which implies that higher is the repayment obligation to the lending agency and hence greater the risk of bankruptcy. This risk is the prime factor for underinvestment. That is, firms might get some external finance to finance their projects, but not to the extent that they desire.

There are many situations when the firm may report that financial factors are constraining innovation. The prerequisite is that the firm is attempting to undertake innovative activity. The firm must then consider that its attempt to pursue that activity has been hampered by the lack of finance and or the cost of that finance. It need not be that all firms that are financially constrained would report that they are financially constrained, for example, they may not be innovation active in the period, or they may face other kinds of constraints that inhibit their R&D activities, which imply that financial constraint is not binding.

The aim of the paper is twin fold. The first is to study the effect of financial constraint, as reported by the firms among other variables, on innovation activity here measured by R&D investment, and secondly, to establish determinants of financial constraint.

There are many problems one faces when estimating the impact of financial and other variables on innovation, selection and endogeneity of the explanatory variables being the chief among them. Problems of sample selection arise since only those firms report R&D expenditure that chose to indulge in R&D activities. Savignac (2005) examines the impact of financial constraints on innovation for established firms in France. An indicator based on the firm's assessment of financial constraints is found to significantly reduce the probability that a firm undertakes innovation activities. However, in her paper she only accounts for the endogeneity of the indicator, indicating whether a firm is financially constrained or not. But, endogeneity of other control variables could also lead to inconsistent estimates. To overcome the potential endogeneity of the regressors we use Lewbel's approach to handling such problems. For studying the determinants of R&D investment we use Lewbel's (2006) semiparametric estimator that handles both the problem of selection and endogeneity. For the binary response model, in which we study the determinants of financial constraint we employ Lewbel's (2000, 2004) semiparametric binary choice model that accounts for endogeneity of the regressors.

Our results generally support the view that financial constraints affect R&D investment and that the financial constraints are less binding in the presence of other constraints on innovation, such as market or economic uncertainty or regulation and organizational rigidities. Other significant determinants of R&D investment that we find are the age of the firms, market share, cooperation in R&D activities and firms' share of innovative sales.

Ideally, we would have liked to assess the impact of the financial position of the firms after controlling for investment opportunities or future expected profitability. However, the Community Innovation Surveys do not provide us with the balance sheet information of the firms. Instead of this financial information we include age and a dummy for group membership of the firm. Our results suggest that age and belonging to a group are significant determinants of financial constraint. We believe that these variables pick up the effect of financial health of the firm. Our results also suggest that the presence of other constraints on innovation, such as market uncertainty, regulation and organizational rigidities, also reduces the probability of a firm being financially constrained though not significantly so. Expected future profitability, as proxied by the share of innovative sales in the total sales of the firm, increases the probability of financial constraint after controlling for information costs that are implied by the financial position of the firm, which is proxied by age, market share and a dummy for belonging to a group.

The rest of the paper is organized as follows. Section 2 describes the data. Section 3 presents the theoretical model of R&D investment in the presence of financial constraints and section 4 the empirical model. Section 5 discusses the results and section 6 concludes.

2 Data

The data used for our analysis are collected by Statistics Netherlands. The Dutch Innovation Surveys are conducted every two years. To implement our model we use the fourth Dutch Innovation Survey, CIS 3.5, which pertains to the years 2000-02. The Innovation Survey data are collected at the enterprise level. A combination of a census and a stratified random sampling is used. A census is used for the population of large (250 or more employees) enterprises, and stratified random sampling is used for small and medium sized enterprises. The size of an enterprise is measured by the number of employees, and the stratum variables are the economic activity and the size of an enterprise, where the economic activity is given by the Dutch standard industrial classification.

Since in our model we want to control for the endogeneity of the regressors, we use as instruments lagged values of some of our potential endogenous regressors. Hence we merged CIS 3.5 with the CIS 3, containing information for the years 1998-2000. This leaves us, after cleaning the data, with a total of 3958 enterprises for our analysis out of which 1531 report to be innovating.

Appendix C shows a table that is directly borrowed from the CIS 3.5 questionnaire. Section 8a of the table asks an innovating firm if it is hampered in its pursuit of innovating activities. Section 8b of the questionnaire asks the non-innovating firms if it is important for them to take up innovating activity and whether they are hampered in some way or another. The number of non-innovating firms that answer in the affirmative to question 8b is 95. These 95 firms could be thought of as potentially innovating firms. Thus the total number of innovating and potentially innovating firms is 1626. If either type of firm, innovating as well as potentially innovating, replies in the affirmative to the general hampering question then it is asked to fill out Section 9, in which it is asked to specify the hampering factor(s) and to what extent it affects its innovation projects. We construct a binary variable *DFIN* that takes value 1 if the firm answers that, because of financial problems, some of its projects are (a) seriously delayed, (b) prematurely stopped or (c) did not start. Out of 1626 innovating as well as potentially innovating firms, 583 firms report that they are hampered in some way or another in their innovation activities. Of these, 178 firms report that they are hampered due to financial reasons.

3 The Theoretical Model

In this section we present a model of financial constraint and then study the decision of the firm to innovate and how much to invest in R&D in the presence of financial constraint[ii] . We refer to appendix A for a discussion of the model.

Firms wish to undertake risky ventures but lack the necessary resources, so they turn to the investors (banks or other deposit-taking, financial institutions) for external finance. Venture capital and other types of non-deposit private equity are not considered in our analysis. The firm is assumed to be risk-neutral; it maximizes the expected value of its "wealth". The returns to the risky venture are described by a revenue function *f*: an investment of *R* units produces a revenue of *f*(*s*, *R*) units in state *s*, *s* being the state of nature. The revenue function is also assumed to exhibit decreasing returns to scale. Assume that $f(s,R) = s\phi(R;.)$, "." represents other parameters characterizing the firm. A crucial assumption is that agents have asymmetric information. The firm observes the state free of charge, but the lender can only observe the state by paying some observational cost. Gale and Hellwig (1985) have shown that the optimal contract between the firm and the lender is a standard debt contract that involves a fixed repayment obligation and a declaration of bankruptcy if and only if the repayment obligation cannot be met, and a confiscation of whatever wealth remains in the event of bankruptcy.

Under an optimal contract the firm maximizes its wealth taking into account the possible risk of bankruptcy and subject to the constraint that the zero profit condition of the lender is satisfied. The zero profit condition states that the expected return from lending to the firm should at least be equal to the amount that the lender can earn from lending this amount at the risk free rate of interest *ir*. Let R_{op} be the amount of R&D capital demanded by the firm under an optimal contract.

To invoke the notion of financial constraint, let us now see what happens under the assumption that both the lender and the firm can directly observe the state of nature. In such a situation, which is termed first best, since the firm and the lender share the same information about the nature of the project and the lender can costlessly observe the states of nature, the problem is the same for the firm and for the lender.

Let R_{fb} be the solution to the firm's problem under the first best situation. Gale and Hellwig (1985) have shown that $R_{fb} \geq R_{op}$ that is to say that the amount of R&D capital demanded in the first best situation is at least as great as the amount lent under an optimal contract. R_{fb} is strictly greater than R_{op} if there is a positive probability of bankruptcy and if the cost borne by the lender for investigation in the event of bankruptcy is positive.

However, it should be noted that R_{op} is a function of the distribution of the states of nature over which it bases its expectations and which we seek to capture through the expected future profitability $E(\pi)$, firm characteristics *FC*, the organizational and the institutional constraints that the firm faces and which deter a firm from taking up R&D activities *CON*, the liquid wealth W_0 that the firm has at its disposal, and the risk free rate of interest *ir*.

$$R_{op} = R_{op}(E(\pi), FC, CON, ir) \tag{1}$$

Gale and Hellwig (1985, 1986) and Gomes et al. (2006) show that $R'_{op_{ir}} < 0$, $R'_{op_W} > 0$. It can be shown that $R'_{op_E} > 0$ and $R'_{op_{CON}} < 0$. In words this means that as the risk free rate of interest rises the demand for R&D capital decreases, as the liquid wealth of the firm increases the demand for R&D capital increases and as the future expected profitability, $E(\pi)$, increases the demand for R&D capital increases. Also since the fixed payment to the lender when the firm is solvent increases with the amount lent, the effects of *ir*, W_0 , $E(\pi)$, and *CON* on the fixed payment to the lender are qualitatively the same as those on R_{op}.

Let r be the equilibrium rate of interest that the firm pays so that the lender's zero-profit constraint is satisfied. This rate of interest is the interest rate actually paid by the firm when it is not bankrupt. This implies that

$$r = r(R_{op}).$$

Since the fixed repayment obligation by the firm to the lender increases with the amount of loan it can be shown that the rate of interest is non-decreasing in the amount of R&D demanded under an optimal contract. Equation (1) implies that

$$r = r(E(\pi), FC, CON, ir)\ . \tag{2}$$

Since the demand for R&D capital increases in expectation of future profitability it can be shown that $r'_E > 0$ and since the demand decreases due to presence of institutional factors that hamper R&D activities, $r'_{CON} < 0$. Also since the demand for external sources of funding decreases with the increase in the internal wealth of the firm, this implies that $r'_{W_0} < 0$.

Define the function fin[iii] as

$$fin = fin\{(E(\pi), FC, CON, ir), \varepsilon\}, \tag{3}$$

where, ε is an idiosyncratic disturbance term. The inequalities discussed above imply that $fin'_E \geq 0$, $fin'_{CON} \leq 0$ and $fin'_{W_0} \leq 0$. We say that a firm is financially constrained if,

$$fin \geq F\ , \tag{4}$$

where F corresponds to the threshold value on the loan that the firm can get. This constraint becomes binding if the rate of interest demanded by the lender on extra units of loan exceeds a certain threshold that the firm is unable to meet. Consequently, the firm would not be able to meet its required R&D investment level. The rate of interest corresponding to the threshold could be thought of as the interest rate on the maximum amount of debt a firm can incur. This threshold can differ from firm to firm depending on the financial position of the firm. Take the example of two firms that are equal in every respect but one firm has a better financial position than the other. The firm that is in a better financial position is less likely to hit its debt limit than the firm whose financial position is not sound. It should be noted that what is driving these results is the positive probability of bankruptcy. Ceteris paribus, the worse the financial position of the firm, the greater is the loan demanded, which implies that the fixed repayment obligation and the risk of bankruptcy are also greater.

4 The Empirical Model

Before we set up our econometric model we would like to note that the observed R&D expenditure corresponds to R_{op}, the optimal R&D capital demanded under the optimal/standard debt contract, but the observed outcome is closer to the first best level if the firm does not report that it is financially constrained. Our objective here is to assess how the observed outcome/R&D expenditure behaves under the presence of financial constraint.

We hypothesize that

$$DFIN = I[fin - F > 0], \tag{5}$$

where *DFIN* is the binary variable that takes value 1 if the firm reports that it is financially constrained and 0 otherwise and *I* is the indicator function that equals one if its argument is true and zero otherwise.

For our empirical analysis of the effects of financial constraints on R&D investment we now seek to set up a model, whose estimation will help us judge the effects of financial constraint on R&D investment. Any such empirical model would have to take into account the sample selection that arises in our data set. Also, in a model of sample selection, common unobservables may affect both the outcome (R&D investment) and the probability of selection (the decision to innovate) in unknown ways. To handle endogeneity in a model of sample selection we use Lewbel's (2006) estimator, which takes the form of simple weighted averages, GMM or two stage least squares. Lewbel shows that the distribution function of potential outcomes, conditional on covariates, can be identified given an observed variable *V*, called very exogenous variable, that affects the selection probability in certain ways and is conditionally independent of the error terms in a model of potential outcomes. The nice thing about this estimator is that it is semiparametric and there are no stringent assumption on the error terms[iv] .

We specify the model below. Equation (6) is our main regression equation in which we seek to establish our determinants of R&D intensity, (7) is our innovator selection equation, and (8) is the indicator function given in (5).

Let LR_i be log of R&D intensity of a plant *i*, where R&D intensity is defined as level of R&D investment in a year divided by the year value of the plant *i's* sales ,

$$LR_i = (SINV_i\beta_1 + DFIN_i\beta_2 + X_i\beta_3 + V_i\beta_4 + \varepsilon_i)D_i \tag{6}$$

$$D_i = I[0 \leq V_i + M(SINV_i, DFIN_i, X_i, e_i)] \tag{7}$$

$$DFIN_i = I[fin_i - F_i > 0], \tag{8}$$

where D_i equals one if the firm *i* is an innovator and zero otherwise. If D_i=1 we observe some R&D expenditure which may also be zero. In our estimation we use log of R&D intensity instead of R&D expenditure. For those firms that are innovators and for whom R&D intensity is zero[v] , log of R&D intensity is taken to be a little lower than the lowest R&D intensity for a firm with positive R&D expenditure. We do this because logarithmic transformation of zero is not defined and therefore such an exercise prevents us from losing any data during estimation.

Our variable *V*[vi] , the very exogenous regressor, is the size of firms measured in terms of employment. The assumption on *V* is that it is an observed, continuously distributed covariate (or known function of covariates) with large support. The coefficient on *V* has been normalized to 1. In the Schumpeterian tradition, it makes sense to include size as an explanatory variable in the main as well as the selection equation. It can also be argued that if there are fixed costs of investing, then as Cohen and Klepper (1996) argue, large firms are more incited to engage in innovative activities because they can amortize these costs by selling more units of output[vii] .

M is an unobserved latent variable which is a function of explanatory variables other than size. We also assume *M* to be linear function of its arguments. *I* is the indicator function that equals one if its argument is true and zero otherwise.

SINV is the share of sales with innovative products in total sales of the firm. Analogous to the literature on physical investment *SINV* could be thought of as a proxy for *q* which is the expectation of the marginal contribution of new capital goods to future profit. We also experimented with alternative proxies for *q*, like lagged values of share of Innovation[viii] . Mulkay et al. (2001) assess the impact of cash flow or profits on R&D and physical investment. The share of sales with innovative products in total sales could be a more accurate measure of the value accruing out of R&D investment than cash flow or profits.

Below are listed the other explanatory variables included in X in equations (6) and (7):

DOTH: This variable caries the effect of other hampering factors. This is a dummy variable that takes value one if a firm is constrained because of one of the following factors: (a) internal organization, (b) market uncertainties, or (c) regulation. The primary aim of constructing this variable is to see the effect of other hampering factors as uncertainty or institutional factors such as regulation and organizational rigidities on R&D intensity and to see the effect of financial constraint in the presence of such factors.

DCOOPERATION: The literature on cooperation and R&D activities is not sparse. The crux of the issue lies in knowledge spillover and its effect on investment. Spillovers increase the relative profitability of R&D cooperation once spillovers are sufficiently high. But higher spillovers also increase the incentives to cheat by partner firms and the profits from free riding. Firms can increase the effectiveness of incoming spillovers by investing in "absorptive capacity". Cohen and Levinthal (1989) show that external knowledge is more effective for the innovation process when the firm engages in own R&D. Increased absorptive capacity through investments in internal R&D efforts thus increases the effectiveness of incoming information. Also when firms are not direct competitors but market independent or produce complementary goods, cooperation is associated with higher R&D investment levels independently of the amount of spillovers.

AGE[ix]: In our specification we also include the age of the firms. CIS data do not provide this information. The birth date of the firm was obtained from the Business Register.

LOG(*MKTSHARE*): This variable is a logarithmic transformation of the market share, defined as the ratio of sales of the firm to the total sales of the industry. It is a proxy for concentration or the degree of monopoly. Schumpeter (1942) argues that a firm is incited to innovate if it enjoys a monopoly position to prevent entry of potential rivals.

Innovating firms are asked if they have introduced new products or processes into the market, and if so, if the new products or processes are (a) developed by the enterprise, (b) developed in alliance with third parties, or (c) developed mainly by third parties.

PDOTH is a dummy equal to one if the new products were developed mainly by third parties.

PDALOTH is a dummy equal to one if the introduced new products were developed in alliance with third parties.

PCOTH is a dummy equal to one if the introduced new processes were developed mainly by third parties.

PCAOTH is a dummy with value one if the new process were developed in alliance with third parties.

< INSERT TABLE 1 >

The rationale for including these dummies in the specification can be found in Table 1. It is evident from that Table that the R&D intensity monotonically decreases with the degree of alliance. However, it should be mentioned that this is not the same as cooperation in R&D activities with other institutions. Summary statistics reveal, see Table 2, that the mean R&D intensity is higher for those firms that have entered into cooperative arrangements with other institution than for those that have not, but also that the R&D intensity monotonically decreases with the degree of alliance in the introduction of new products or processes.

< INSERT TABLE 2 >

In our specifications we also include a dummy variable *DSINPL*, that takes value one if the enterprise does not belong to a group headed by a company that has more than one enterprises working for it. It could be quite possible that the firm in question, if faced with financial distress, could be bailed out by the company to which it belongs. It is also possible that the company to which this enterprise belongs engages in diverse activities and produces diverse products which reduces its risk of being bankrupt, thus enhancing its ability to borrow more.

Earlier we have explained the construction of our binary variables *DFIN*. In our bid to explain what causes financial constraint we use Lewbel's (2000, 2004) semiparametric estimator to estimate a binary choice model. For our estimation we choose a simple functional form for the function, *fin-F*, which is given by

$$fin_i - F_i = V_i + R(X_i, \varepsilon_i),$$

where *V* and *X* include variables that parameterize the arguments in the function *fin*. *R* is a latent variable, which we assume to be a linear function of variables other than *V*, the very exogenous regressor, and the error term [epsilon]. Thus, the estimation equation is given by the following equation:

$$DFIN_i = I[0 \leq V_i + R(X_i, \varepsilon_i)]$$

V in our model is the size of firms measured in terms of employment. The coefficient on *V* has been normalized to 1. The assumption on *V* is that it is an observed, continuously distributed covariate (or known function of covariates) with large support[x] . It is known that small firms may be more tightly constrained because they have less access to internally generated funds for the financing of an innovation project and therefore have to approach outside financiers. These considerations imply that the size of the firm has a bearing on the financial wealth of the firm, especially with respect to financing of R&D investment from internal funds. Problems of information asymmetries may also be more severe for small firms in terms of raising outside finance. Moreover for smaller, newer firms there may be no track record upon which to base a case for funding and/or there may be fewer realizable assets to use as collateral. Thus size may have an implication in raising the required rate of return independently of the financial position of the firms.

For the same reason as stated in the model on R&D intensity we use $SINV_i$, the share of sales with innovative products in total sales of the firm, as a proxy for future expected profitability.

As mentioned earlier, a proper explanation of a firm being financially constrained necessitates information on the balance sheet of the firms. But since we do not have such information we use the age of the firm, the log of market share, and a dummy if a firm belongs to a group, as proxies for wealth. We include the age of the firm since it might be the case that long established firms that have survived exit are financially better than the new entrants. Age carries a reputation effect which can have a bearing on accessibility to outside funds.

5 Results

The section discussing the results has two subsections. The first section discusses the results of the sample selection model in which we establish the determinants of R&D intensity and the next section discusses the result of the binary choice model, where we seek to explain the probability of a firm being financially constrained.

< INSERT TABLE 3 >

5.1 R&D Intensity

In this subsection, we discuss the results of the effect of the financial variable, *DFIN*, after controlling for the effect of other variables that influence the choice of R&D investment.

Table 3 presents the result for R&D intensity. The estimates in the columns only differ in the choice of instruments. The common set of instruments for the two columns are the age of the firm (*AGE)*; the logarithm of market share (*LOG*(*MKTSHARE*)), the lagged dummy variable for being financially constrained ($DFIN_{-1}$); the lag of the share of innovative sales in the total output of the firm ($SINV_{-1}$); the lag of the dummy equal to 1 if the firm cooperated with others in its R&D endeavors ($DCOOPERATION_{-1}$); the lag of the log of market share, ($LOG(MKTSHARE)_{-1}$); the dummy set equal to one if the firm did not belong to a group (*DSINPL)*; the dummy indicating if the firm also did non technological innovation (*DNONTECH)* and its lag ($DNONTECH_{-1}$); the dummy that is equal to one if new products were developed in alliance with third parties (*PDALOTH)*; the dummy that takes value one if new processes were developed in alliance with third parties (*PCALOTH*); the dummy variable that takes value 1 if non-technological reasons or market oriented reasons were important in driving innovation activities (*NONTECHR)*; the dummy variable that takes value 1 if technological reasons were important in driving innovation activities (*TECHR)*; total investment of the firm during the last period ($INVT_{-1}$); and industry dummies. The instrument set in column (a) includes an additional variable *PDOTH,* which is a dummy set equal to one if the new products were developed mainly by third parties. Some of the variables in the list of instruments, like TECHR and NONTECHR, turned out to be insignificant and were therefore not included among the explanatory variables.

The number of over identifying restrictions (number of instruments minus number of estimated coefficients) is equal to 2 in column (a) and 3 in column (b). The specifications in both columns satisfy the Sargan test that the over identifying orthogonality restrictions are not significantly different from zero.

The results from the estimates suggest that, once other factors are controlled for, a firm is adversely affected in its pursuit of R&D activities, as measured by the R&D intensity, by the presence of financial constraints. The large negative sign on *DFIN* is testament to this fact. From our discussion of the model we know that, given the uncertainty, the risk of bankruptcy is large for firms that are not financially healthy. This risk plays an important part in reducing the amount of R&D investment. We include *DOTH* to assess the effect of other constraints. The results of our analysis suggest that such factors on their own also have a negative effect on the amount of R&D capital a firm wishes to use. The effects of the other constraints are much weaker than the financial constraints suggesting that, if there are any major hampering factors, then these are financial constraints. To capture the effect of financial constraints in the presence of other hampering factors, we include the interaction of *DFIN* and *DOTH*, *DFIN***DOTH*. Our results imply that financial constraints are less binding if market uncertainties, institutional, or other hampering factors are also present (the coefficient of *DFIN***DOTH* is positive and statistically significant). The effect of financial constraints in the presence of other constraints is captured by the sum of the coefficients of *DFIN*, *DFIN***DOTH,* and *DOTH*. The F-statistic corresponding to the test of the null hypothesis that the sum of these coefficients is equal to zero is reported at the bottom of table 3. The restriction is marginally rejected in column (b) but not in column (a). The estimated coefficients are rather similar in both columns. We can thus conclude that the total effect of all constraints is not significantly different from zero, but that the financial constraints alone are quite prominent and negatively affect the R&D intensity.

Our results suggest that R&D intensity reacts strongly to *SINV*, which is the share of sales with innovative products in the total sales of the firm that we assumed to be a proxy for future expected profitability. The strong positive sign on *SINV* suggests that the higher is the future expected profitability, the higher is the R&D intensity. However, we find that firms that have a higher market share also have a lower R&D intensity. Not surprisingly, the sign of this coefficient is positive when we use the logarithm of R&D expenditure instead of the logarithm of R&D intensity as the dependent variable. These findings are not new; they only suggest that a monopoly firm does indeed invest more than a firm in a more competitive industry but proportionately less as it increases in size, as measured by sales[xi] . Our results suggest that, controlling for other factors, older firms tend to have a higher R&D intensity than younger firms and that the spillover effects of cooperation lead to higher R&D intensity. It could also suggest that the cooperative arrangements are made with non-rivals or with firms that are engaged in producing complementary goods[xii] . The negative sign of variable *DSINPL* indicates that firms that do not belong to a group have a lower R&D intensity than those that do belong to a group. Enterprises belonging to a group could be special units, set up with the purpose of carrying out R&D activities for the whole group.

5.2 Financial Constraint

This section discusses the results of the binary choice models in which we seek to explain the determinants of the financial constraint itself. Our dependent variable is *DFIN* which is the binary variable that takes value one if the firms finds itself being financially constrained and zero otherwise. As stated earlier, to handle the potential endogeneity of the regressors we use Lewbel's (2000, 2004) semiparametric estimator.

To estimate the binary choice model we construct another dependent variable $DFIN^*$, which is $DFIN\text{-}I(V \geq 0)$ weighted by the inverse of the conditional density function of the negative of the logarithm of the size of the firm, measured in terms of employment, the very exogenous variable *V,* to use the same notation as in Lewbel's (2000, 2004) papers. *I* is an indicator variable that takes value 1 if the argument in parentheses is true. The conditioning variable is the union of all the explanatory variables and the instruments. We take the negative of the logarithm of size because one of the assumptions of the model is that, as *V* decreases, the probability of *DFIN* being zero increases (refer to footnote 9). In Lewbel's method, the division by the conditional density of V, converts V to a uniform distribution.

The results of the binary choice model in which we seek to explain the determinants of financial constraint are presented in Table 4. The set of instruments in all columns contains *DOTH*, $DOTH_{-1}$, *AGE*, *DSINPL*, *LOG*(*MKTSHARE*), $LOG(MKTSHARE)_{-1}$, $DCOOPERATION_{-1}$, *PDOTH*, *PDALOTH*, *PCALOTH*, *PCOTH*, $SINV_{-1}$, *DNONTECH*, $DNONTECH_{-1}$, lagged size, and sectoral dummies.

The more striking results of this part of our analysis are the coefficient estimates that we obtain on age and DSINPL. The results suggest that the more aged a firm is, the less likely it is to be financially constrained and significantly so. This is understandable, since older firms, having survived preemption, are more likely to be financially stable than new firms. Also, older firms have a better reputation than younger firms, and therefore they have greater access to external funds. Secondly, the estimation results indicate that a firm is more likely to be financially constrained if it does not belong to a group. This could suggest that if it belongs to a group, then it has at its disposal some alternative avenues of financing its projects that are closed to firms that do not belong to a group. The fact that it belongs to a group may be an indication that the group is engaged in diverse activities and thus less prone to risk than a single enterprise engaged in a single activity. As explained earlier, *DFIN* is a function of the financial state variables. In the absence of information on the balance sheets, the effect of financial state variables is included in the error term. Hence, the instruments that are supposed to be correlated with the regressors are also correlated with the error term. But since the results of the test of over identifying restrictions do not lead to rejection, we conclude that age and the dummy indicating that the firm belongs to group are picking up the effects of financial variables.

As explained earlier the binary variable *DFIN* is an indicator of the firm's willingness to undertake R&D activity as well as of its financial position. As a proxy for future expected profitability we experiment both with the current value of the share of innovative sales *SINV* and with its lag. Our results suggest that controlling for other variables, the probability of a firm being financially constrained is higher, the higher is its future expected profitability, as proxied by *SINV* or its lag, but not significantly so.

The results in Table 4 also suggest that a firm facing a priori hampering factors other than financial constraints are less willing to undertake R&D activities and are thus less likely to be hit by financial constraints. The results on over identification restrictions do not suggest that there is simultaneity in the determination of *DOTH* and *DFIN*, since *DOTH* is included in the instrumental variables.

6 Conclusions

In this paper we empirically investigate the determinants of R&D and investment. In particular, our aim is to see how financial constraints affect a firm's R&D intensity. We find that a firm that reports that it is financially constrained but not otherwise constrained is adversely affected in its pursuit of R&D activity. Financial constraints have a large and a significant impact in affecting R&D investment.

However, financial constraints are less binding if the firm runs up into other hampering factors or other constraints that are not a function of financial constraint itself. We obtain this result both by looking at the effect of financial constraint on R&D intensity in the presence of other constraints, such as market uncertainty, institutional constraints and organizational rigidities, and looking at the probability for a firm to be financially constrained in the presence of other than financial constraints. We also find that the effect of these other constraints is much weaker than that of financial constraint, which confirms the findings of many papers that financial factors are the major stumbling block in pursuit of any activity. However, this does not diminish the fact that institutional and organizational rigidities also reduce the amount or R&D investment. Policy makers while taking into account the hampering factors that inhibit R&D activities should also consider such factors. Also, since financial constraint seems to be the most important factor that inhibits R&D activities, policy makers should consider setting up institutions that would allow economically sound projects get the required finance to be carried out. In particular, care should be taken of young firms and firms that do not belong to a group, since these firms are the ones that are more susceptible to the exigencies of nature, as is well reflected in our analysis. Finally, as a comment on financial constraint, we note that, age and group membership, as proxies for the financial wealth of a firm, appear to be significant predictors of a firm being financially constrained.

One of the shortcomings of our paper is that, we have not used financial information from the balance sheet of the firms, but instead used proxies for financial state variables. As a part of our future research agenda we would like to enrich our model by using data from the balance sheet of the firms in the explanation of financial constraint. Also, for our future research we plan to carry out our investigation of financial constraint on R&D investment in a dynamic setting by using more waves of CIS data. This would also necessitate a dynamic model of financial constraint and investment.

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Appendix A   A Model of Financial Constraint

In this appendix we present a model of financial constraint and study the decision of a firm to innovate and how much to invest in R&D in the presence of financial constraints[xiii] . Firms wish to undertake risky ventures but lack the necessary resources, so they turn to the investors, banks or other deposit-taking, financial institutions, for external finance. Venture capital and other types of non-deposit private equity are not considered in our analysis. The firm's initial net wealth is $W_0=A_0-R_0$, where A_0 is the firms's initial liquid assets and R_0 the firm's initial indebtedness. Assume that the firms need of R&D expenditure R is greater than W_0. The firm is assumed to be risk-neutral; it maximizes the expected present value of its "wealth". The returns to the risky venture are described by a revenue function f: an investment of R units produces a revenue of $f(s,R)$ units in state s, s being the state of nature. The revenue function is also assumed to exhibit decreasing returns to scale. Assume that $f(s,R) = s\phi(R;.)$, "." represents other parameters characterizing the firm. A crucial assumption is that agents have asymmetric information. The firm observes the states free of charge, but the lender can only observe the states by paying some observational cost. Gale and Hellwig (1985) have shown that the optimal contract between the firm and the lender is a standard debt contract, which involves a fixed repayment obligation $\overline{R}_l$, and a declaration of bankruptcy if and only if the repayment obligation cannot be met, and a confiscation of whatever wealth remains in the event of bankruptcy.

Under an optimal contract the firm takes into account the possible chances of bankruptcy. If the firm declares bankruptcy its revenue is reduced to $\alpha s\phi(R;.)$, where

0≤α≤1, and it suffers a fixed nonpecuniary penalty whose monetary equivalent is K≥0. Under an optimal contract the firm solves the following problem:

$$\max_{R,\bar{R}} E[s\phi(R;FC,CON)-\overline{R_l}]^{+}-\Pr[s\phi(R;FC,CON)<\overline{R_l}] \quad (10)$$

subject to

$$E\tilde{R}_l \geq (1+ir)(R-W_0) \quad (11)$$

$$R \geq 0,$$

where $[X]^{+}\equiv\max\{X,0\}$, $\Pr[.]$, denotes a probability, the expectation is taken over the states of nature, *ir* is the risk free rate of return, *FC* is firm characteristics, *CON* is other constraints such as institutional factors that deter firms from taking up R&D activities and $\tilde{R}_l$ is given by

$$\tilde{R}=\bar{R} \qquad \text{if } s\phi(R;.)\geq\overline{R_l}\text{, and}$$

$$\tilde{R}=\alpha s\phi(R;.) \text{ if } s\phi(R;.)<\overline{R_l}\,.$$

$\tilde{R}_l$ is a random variable, which is the lender's gross return under a standard debt contract. $\overline{R}_l$, under the standard debt contract is the fixed payment to the lender when the firm is solvent. In the event of bankruptcy, that is, if $s\phi(R;.)<\overline{R_l}$, the revenue is reduced to $\alpha s\phi(R;.)$, and since the lender is allowed to recoup whatever he/she can, the lender's revenue in the state of bankruptcy is $\alpha s\phi(R;.)$. One can interpret $(1-\alpha)s\phi(R;.)$ as the cost borne by the lender for investigation in the event bankruptcy. Equation (11) is the zero profit condition of the lender, which states that the expected return from lending to the firm should be at least equal the amount he/she can earn from lending the same amount at the risk free rate of interest *ir*. Let R_{op} be the solution to (10) and (11).

To invoke the notion of financial constraint let us now see what happens under the assumption that both the lender and the firm can directly observe the state of nature. In such a situation, which is termed first best, since the firm and the lender share the same information about the nature of the project and the lender can costlessly observe the states of nature, the problem of firm as well as the lender is the same. This can be written as

$$\max_R E\{sf(R,.) - (1 + ir)(R - W_0)\}. \tag{12}$$

Let, R_{fb} be the solution to the above problem. Gale and Hellwig (1985) have shown that $R_{fb} \geq R_{op}$ and that $R_{fb} > R_{op}$ if $\Pr[s\phi(R,.) < \overline{R}_l] > 0$ and α<1, that is to say that the amount R&D capital demanded in the first best situation is at least as great as the amount lent under an optimal contract and is strictly greater if there is a positive probability of bankruptcy and if the cost borne by the lender $(1-\alpha)s\phi(R;.)$ is positive.

Let r be the equilibrium rate of interest that the firm pays so that the lender's zero-profit constraint is satisfied. This rate of interest r in (13) is the interest rate actually paid by the firm when it is not bankrupt and is given by:

$$(1 + r)(R_{op} - W_0) = \overline{R}_l .$$

(13)

This implies that

$$r = r(R_{op}, \overline{R}_l) .$$

However, it should be noted that both R_{op} and $\overline{R}_l$ are determined simultaneously and are functions of the distribution of the states of nature, which we denote here by $h(s)$; firm characteristics, FC; the organizational and the institutional constraints that the firm faces and which deters a firm from taking up R&D activities, *CON*; the liquid wealth W_0 that the firm has at its disposal and the risk free rate of interest *ir*. Hence

$$R_{op} = R_{op}(E(\pi), FC, CON, ir),$$

(14)

and

$$\overline{R}_l = \overline{R}_l(E(\pi), FC, CON, ir). \quad (15)$$

Here we seek to capture the distribution of the states of nature on which a firm bases its expectation with a single variable, $E(\pi)$, the expected future profitability and is given by $E(\pi) \equiv E[s\phi'(R)] = \int s\phi'(R)h(s)ds$.

Gale and Hellwig (1985, 1986) and Gomes, Yaron, and Zhang (2006) show that $R'_{op_{ir}} < 0$, $R'_{op_W} > 0$ [xiv], where " ′ " denotes the derivative of the variable with respect to the subscript variable. It can also be shown that $R'_{op_E} > 0$ and $R'_{op_{CON}} < 0$. In words this means that as the risk free rate of interest rises the demand for R&D capital decreases, as the liquid wealth of the firm increases the demand for R&D capital decreases and as the future expected profitability, $E(\pi)$ increases the demand for R&D capital increases. Also since the fixed payment to the lender when the firm is solvent, $\overline{R}_l$, increases with the amount lent, the effect of *ir*, W_0, $E(\pi)$, and *CON* on $\overline{R}_l$ are qualitatively the same as those on R_{op}.

Equation (14) and (15) imply that[xv]

$$r = r(E(\pi), FC, CON, ir). \quad (16)$$

Since the demand for R&D capital increases in expectation of future profitability it can be shown that $r'_E > 0$ and since the demand decreases due to presence of institutional factors that hamper R&D activities, $r'_{CON} < 0$. Also since the demand for external sources of funding decreases with the increase in the internal wealth of the firm, this implies that $r'_{W_0} < 0$. Define the function fin[xvi] as

$$fin = fin\{(E(\pi), FC, CON, ir), \varepsilon\}, \tag{17}$$

where ε is an idiosyncratic disturbance term. The inequalities discussed above imply that $fin'_E \geq 0$, $fin'_{CON} \leq 0$, and $fin'_{W_0} \leq 0$. We say that a firm is financially constrained if,

$$fin \geq F \tag{18}$$

that is, if the rate of interest demanded by the lender on an extra unit of loan exceeds a certain threshold, which the firm is unable to meet. Consequently the firm would not be able to meet its required R&D investment level. The rate of interest corresponding to the threshold could be thought of as the interest rate on the maximum amount of debt a firm can incur. This threshold can differ from firm to firm depending on the financial position of the firm. For example, consider two firms that are equal in every respect but one firm has a better financial position than the other. The firm that is in a better financial position is less likely to hit its debt limit than the firm whose financial position is not sound. It should be noted that what is driving these results is the positive probability of bankruptcy. Ceteris paribus, worse the financial position of the firm, greater is the loan demanded which implies higher the fixed repayment obligation and thus greater the chances of bankruptcy.

Appendix B A Note on Estimation

Given our estimation model equation (6) and (7)

$$LR = (SINV\beta_1 + DFIN\beta_2 + X\beta_3 + V\beta_4 + \varepsilon)D$$

$$D = I[0 \leq V + M(SINV, DFIN, X, e)]$$

where *LR*, the log of R&D intensity is the outcome and *D* is the decision variable to innovate. *D* takes value = 1 if the firm chooses to innovate and zero otherwise. Define

$$U^* = Z(LR^* - (SINV\beta_1 + DFIN\beta_2 + X\beta_3 + V\beta_4)),$$

where *Z* is the vector of instruments and LR^* is the unobserved R&D intensity for firms which report to be non-innovators and therefore do not report their R&D intensity. In such a situation the coefficients of the model could be estimated by two stage least squares or a GMM technique using the moment condition $E(U^*) = 0$. But what we observe in fact is *U*, which is given by

$$U = Z(LR - (SINV\beta_1 + DFIN\beta_2 + X\beta_3 + V\beta_4))D.$$

In the presence of selection, GMM or two stage least squares is infeasible because we only observe *LR* and not LR^*, and unobservables that determine the selection such as *M*, the unobserved latent variable, are correlated with LR^* and U^*. But the estimation of the required coefficients could become feasible given a consistent estimator of $E(U^*)$. Define the weighting scalar *W* by $W=D/f(V|Y)$ where *f* is the conditional probability density function of *V*, introduced earlier, given *Y*, which is the union of the set of instruments and the other covariates, that is, *DFIN*, *SINV* and *X*, that appear in equation (6). Lewbel (2006) shows that

$$E(U^*) = p\lim_{n\to\infty} \frac{\sum_{i=1}^{n}(U_i W_i)}{\sum_{i=1}^{n} W_i}. \tag{19}$$

The main assumptions required for equation (19) to hold are that the support of $V|Y$ contains the support of $-M|Y$ (these could all equal the real line, for example), and that

$$V \mid Y, U^{*}, M \sim V \mid Y \qquad (20)$$

that is, V is conditionally independent of the unobserved latent variables of the model, conditioning on the set of covariates X. Given the above, our estimates are based on the moment conditions:

$$E[ZW(LR - (SINV\beta_1 + DFIN\beta_2 + X\beta_3 + V\beta_4))] = 0 .$$

We estimate the above by using the method of two stage least squares. To estimate the conditional density of V given Y, $f(V|Y)$, we employ the nonparametric density estimator described in Lewbel and Schennach (2007). To obtain estimated standard errors we use the formula's derived by Lewbel. As suggested by Lewbel (2004), we also applied the bootstrap to obtain standard errors. The results appeared to be similar to those obtained using analytical formula's for the asymptotic variances of the estimators. Therefore, we do not report them here.

Appendix C Part of the Questionnaire asking Respondents to fill up Information on Hampering Factors

8. Hampering factors general

a. During 2000-2002, did your enterprise encountered hampering factors leading to seriously delayed, abandoned, not started innovation projects?

- ☐ Yes — go to question 9
- ☐ No — go to question 10

b. In question 2 you have stated that your enterprise did not engage in activities aimed at technological improvements. What was the reason for this?

- For our enterprise it was not necessary to engage in such activities in 2000-2002 ☐ go to question 10
- Such activities were needed, but hampered and therefore NOT started ☐ go to question 9 (last column)

9. Hampering factors and consequences for innovation projects

Tick the consequences of the hampering factors your enterprise experienced in innovation projects in 2000-2002

		Consequences hampering factors: innovation projects are seriously delayed	abandoned	not started
No financing	Lack of appropriate sources of finance	☐	☐	☐
Cost too high	Innovation costs were/became too high	☐	☐	☐
Economic risks	Too much uncertainty of future benefits and costs	☐	☐	☐
Shortage personnel	Lack of *qualified* personnel	☐	☐	☐
Shortage knowledge	Lack of knowledge on technologies needed	☐	☐	☐
Internal organisation	Organisational rigidities within the enterprise	☐	☐	☐
Market uncertainties	Future market developments uncertain	☐	☐	☐
Regulation		☐	☐	☐
Other reason	Namely:	☐	☐	☐

Source: Community Innovation Survey 3

Table 1: **Mean Distribution of R&D Intensity along Alliance in the Introduction in New Products and Process**

	Mainly by your enterprise	Cooperation with third parties	Mainly by third parties
Product	1.45 (1363)	.68 (679)	.35 (296)
Process	1.70 (643)	.77 (601)	.24 (441)

The figures in parentheses are the number of observations.
These numbers are from the full sample of CIS 3.5, which has 10628 observations.

Table 2: **Descriptive Statistics of the Variables of Interest**

Variables for Innovating Firms				
	Mean	St. Dev.	Min	Max
LR	-5.09	3.80	-19.70	4.84
SINV	17.15	22.61	0	100
DCOOPERATION	.41	.49	0	1
PDALOTH	.21	.41	0	1
PDOTH	.08	.28	0	1
PCALOTH	.16	.36	0	1
PCOTH	.08	.28	0	1
Variables for All the Firms				
	Mean	St. Dev.	Min	Max
DFIN	0.04	0.21	0	1
DOTH	0.11	0.32	0	1
*DFIN**DOTH*	0.04	0.18	0	1
LOG(*MKTSHARE*)	-8.88	2.27	-18.26	-0.48
SIZE	218.34	1014.91	2.67	39591.50
DSINPL	0.44	0.50	0	1
AGE	22.37	11.59	2.00	35.00

Table 3: **Determinants of R&D Intensity**

Very Exogenous Variable: Size in 100				
Dependent Variable: Log of R&D Intensity				
	(a)		(b)	
DFIN	-41.65	***	-41.66	***
	(11.44)		(11.45)	
*DFIN*DOTH*	44.44	***	44.45	***
	(11.44)		(11.45)	
DOTH	-1.77	***	-1.74	***
	(0.59)		(0.62)	
DCOOPERATION	0.75	***	0.74	***
	(0.19)		(0.20)	
SINV	0.04	***	0.04	***
	(0.01)		(0.02)	
AGE	0.04	***	0.04	***
	(0.01)		(0.01)	
LOG(MKTSHARE)	-0.18	***	-0.17	***
	(0.04)		(0.04)	
DSINPL	-0.29	*	-0.28	*
	(0.17)		(0.17)	
PDOTH	3.05	***	2.97	***
	(0.45)		(0.73)	
PDALOTH	-0.20		-0.20	
	(0.42)		(0.42)	
PCOTH	-9.57	***	-9.63	***
	(1.24)		(1.31	)
PCALOTH	-1.04	***	-1.05	***
	(0.40)		(0.40)	
Sargan Test	6.04		6.02	
Degrees of Freedom	3		2	
P-Value	0.11		0.05	
F-stat	3.86		3.65	
P-Value	0.049		0.056	

Significance levels: *: 10%, **: 5%, ***: 1%. Industry dummies are controlled for. For list of instruments, see section 5.1

Table 4: **Determinants of Financial Constraint**

Very Exogenous Variable: Log of Size								
Dependent Variable: DFIN, Binary variable indicating if the firm was financially constrained or not								
	(a)		**(b)**		**(c)**		**(d)**	
SINV	0.36		-0.06					
	(0.35)		(0.59)					
$SINV_{-1}$			22.61		20.6		20.87	
			(25.9)		(15.18)		(15.1)	
DOTH	-15.25	*	-13.09		-13.46		-13.31	
	(9.36)		(9.67)		(8.87)		(8.84)	
AGE	-0.96	***	-0.94	***	-0.95	***	-0.95	***
	(0.24)		(0.24)		(0.24)		(0.24)	
LOG(*MKTSHARE*)	0.16		0.27		0.25			
	(1.38)		(1.38)		(1.36)			
DSINPL	17.45	***	17.65	***	17.62	***	17.54	***
	(5.54)		(5.53)		(5.53)		(5.51)	
Sargan Test	13.23		12.51		12.52		12.55	
Degrees of Freedom	10		9		10		11	
P-value	0.21		0.19		0.25		0.32	

Significance levels: *: 10%, **: 5%, ***: 1%. Industry dummies are controlled for. For list of instruments, see section 5.2

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[i]The data collected through CIS are at the enterprise level and not at the company level. Here we use the term firm and enterprise exchangeably.

[ii]See Gale and Hellwig (1985) for a detailed discussion.

[iii]We now ignore the risk free rate of interest *ir*, since it should stay constant for a single period of survey.

[iv]Appendix B carries a note on the estimation.

[v]Out of 1531 innovating firms, 107 or about 7 percent of them do not have R&D expenditure for the period of the survey.

[vi]To make sure that V or the log of size has a large support we demean it. With this exercise, we make sure that V takes negative as well as positive values.

[vii]Nilsen and Schiantarelli (2003) find strong statistical evidence of this relationship, including much greater incidences of zero investments in small versus large plants. They attribute this relevance of plant size both to the presence of absolute as well as relative fixed costs and to potential indivisibilities in investment.

[viii]See Nilsen and Schiantarelli (2003)

[ix]The age of the firms are available from 1967 onwards.

[x]An implication of the large support assumption for V is that, for any value X [and epsilon] may take on, it is possible for V to be small enough to make D=0 , with probability one, or large enough to make D=1 with probability one.

[xi]See Cohen, Levin and Mowery (1987) and Geroski (1990).

[xii]See De Bondt et al. (1992) and Röller et al. (1997).

[xiii]See Gale and Hellwig (1985) for a detailed discussion.

[xiv]However,Gale and Hellwig (1986) show it is not generally true that a reduction in the firm's internal funds leads to a reduction in investment. They show that the relation between the firm's net wealth and investment is exceedingly complicated. Formally, this complexity is due to the nonconvexity that arises from the possibility of bankruptcy. Conceptually, the difficulties arise from the strategic interaction between the borrower's interests and the lender's interests.

To understand the basic difficulty, consider the situation when the firm has some prior debt so that its liquid net wealth is negative. A lender may be willing to roll over the prior debt if he receives an appropriate claim on the surplus that the enterprise generates. In this situation, the lender is likely to insist on an investment level that is sufficient to generate a substantial surplus. If the marginal returns to investment are unaffected by the costs of bankruptcy, e.g., if the cost of bankruptcy is a fixed nonmonetary cost falling on the borrower, then for very low (negative) levels of the firm's net wealth, the chosen investment level will actually be close to the first-best level, because that maximizes the expected surplus that can be made available to the lender. At this point, the marginal bankruptcy cost of investment to the firm becomes irrelevant because the firm only has the choice between an immediate default on its prior debt and an investment policy that is acceptable to the lender.

Thus it may happen that investment is close to the first-best level both if the firm's net wealth is very high so that little outside capital is needed and if the firm's net wealth is very low so that lenders are barely willing to roll over the firm's prior debts.

However, for intermediate wealth levels, investment will be strictly less than the first-best level because the firm takes account of the marginal bankruptcy costs of increased borrowing. In our paper we assume that the wealth level of the firm lies in the region that Gale and Hellwig (1986) characterize as intermediate wealth levels. There are three reasons for this assumption. Firstly, R&D activities are mostly taken by firms that have a reasonably sound financial position, secondly, for our analysis we only take those firms that appear both in CIS3 and CIS3.5, that is those firms who since the last survey have survived till the current survey and hence are either likely to be large or growing firms, and thirdly, if there is a situation, where the lender is likely to insist on an investment level that is sufficient to generate a substantial surplus and the firm only has the choice between an immediate default on its prior debt and an investment policy that is acceptable to the lender then there would be no financial constraint.

[xv]In fact the rate of interest *r* does not have an independent meaning in the context of the model. It is just another characterization of the fixed repayment obligation of the firm, $\overline{R}_l$. We only introduce it here so that we can write the model to be estimated.

[xvi]We now ignore the risk free rate of interest *ir*, since it should stay constant for a single period of survey.