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# Financing Imperfections and the Investment Decisions of Privately Owned Firms

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**Abstract**

Financing constrains on investment are mainly important for small privately owned firms. Yet most of the investment literature focuses on the financing constraints of large publicly owned firms. This paper develops a financing constraints test based on a variable capital investment equation. Because it does not require the information about marginal $q$, the test can be easily applied to small firms not quoted on the stock market. Importantly, the test does not rely on restrictive assumptions about the adjustment costs of fixed capital. We confirm empirically the validity of this test on a sample of small manufacturing firms.

JEL classification: D21, G31

Keywords: Financing Constraints, Investment, Small Firms, Privately Owned Firms, Variable Capital

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# I Introduction

Several empirical papers have studied the relationship between financial structure and firm investment. A theoretical literature has shown that financial factors may be important to understand the investment decisions of firms, because problems such as asymmetric information and contract incompleteness may limit the availability of external finance, and thus prevent the firms from investing optimally (Besanko and Thakor (1986), Milde and Riley (1988), Hart and Moore (1998), Albuquerque and Hopenhayn (2004)).

The motivation of this paper is that while informational and enforceability problems are mostly relevant for the financing of small privately owned firms, the investment literature has almost exclusively studied the financing constraints of large, publicly owned firms quoted on the stock markets. The review by Hubbard (1998) cites no less that 21 papers that study the effects of financing constraints and financial factors on firm investment.[1] All of those focus on large companies whose shares are publicly traded on the stock markets.[2] Also more recent papers focus on large firms only, such as Bond *et al.* (2003) and (2004), Whited (2005), Hennessy *et al.* (2005), Almeida and Campello (2005), Almeida *et al.* (2004).

Among the few exceptions are three papers that study datasets of small firms in developing countries: Jaramillo, Schiantarelli, and Weiss (1996), Gelos and Werner (2002) and Lízal and Svejnar (2002). However the claim that small firms do not matter for developed economies, because large firms account for most of the aggregate employment and output, is not correct. For example, in 1995, small firms with less than 100 employees accounted for 37.9% of the total employment in the US economy (source: US Census).[3] Moreover in the same year the market value of private equity held by US household was 4293 billion US$, while the market value of public equity held by the same households was only 3439 billion US$.[4]

[1]These are: Blanchard and Lopez de Silanes (1994), Blundell *et al.* (1992), Bond and Meghir (1994), Calomiris, Himmelberg and Wachtel (1995), Calomiris and Hubbard (1995), Carpenter, Fazzari and Petersen (1998), Devereux and Schiantarelli (1990), Fazzari and Petersen (1993), Fazzari, Hubbard and Petersen (1988), Gilchrist (1991), Gilchrist and Himmelberg (1995), Himmelberg and Petersen (1994), Hoshi, Kashyap and Scharfstein (1991), Hubbard, Kashap and Withed (1995), Kaplan and Zingales (1997), Kashap, Lamont and Stein (1994), Lamont (1997), Schiantarelli and Sembenelli (1995), Schaller (1993), Shin and Stultz (1998), Withed (1992). For a full reference of the papers that are not already cited in this paper, please refer to Hubbard (1998).

[2]Among these papers Himmelberg and Petersen (1994) consider a sample of publicly owned and R&D intensive firms which are relatively small, with an average size of 237 employees.

[3]The density of small firms is even larger in some of the largest European countries. Bartelsman *et al.* (2003) show that the average firm size in the 1989-94 period was 26 employees in the US, compared to 17 in Western Germany and 11 in Italy.

[4]Source: Moskowitz and Vissing-Jørgensen (2002).

Why has the investment literature mainly focused on large firms for which financing constraints are less likely to be a problem? One explanation is that Fazzari, Hubbard and Petersen (1988), and many authors after them, estimate the effect of financing constraints on firm investment using the $q - model$.[5] This model assumes that investment is a linear function of marginal $q$, the marginal return of one unit of wealth invested in the firm. Fazzari Hubbard and Petersen (1988) propose to detect financing constraints by adding cash flow as an explanatory variable in this model. If a firm is not subject to financing imperfections, its investment should only be responsive to changes in $q$, and cash flow should not be significant. Therefore a positive correlation between investment and cash flow, conditional on $q$, indicates that a firm is financially constrained because it is willing to invest more when it has more internal funds available. One appealing feature of this model is that, under certain conditions (Hayashi, 1982, Abel and Eberly, 1994), the unobservable marginal $q$ is equal to average $Q$, which can be calculated as the ratio of the market value of the firm divided by the replacement value of its assets.

However, because the market value is easily measurable only for publicly traded firms, this approach precludes the analysis of the effects of financing constraints on small privately owned firms.[6] Moreover several studies, starting with Kaplan and Zingales (1997), show that the correlation between fixed investment and cash flow is not a good indicator of financing constraints.[7] In particular Ericson and Whited (2000) and Bond *et al* (2004) argue that measurement errors in $q$ are the reason why cash flow is found to be positive and significant in the estimations of the $q$ model. Other studies emphasize that while the $q$ model relies on the assumption of quadratic adjustment costs of investment, a large body of empirical evidence shows that non-convex adjustment costs, such as fixed cost and irreversibility, are important for fixed capital investment decisions at the firm and at the plant level.[8] Pratap (2003) and Caggese (2005) simulate industries with heterogeneous firms and with financing imperfections and show that, when fixed

[5] Another simple explanation, that reliable panel data of firms are only available for large public owned companies, is no longer valid. For example the database Amadeus of Bureau Van Djik contains balance sheet data for up to 10 years for 8 million european companies. The database Orbis, from the same provider, has data on over 1.7 million US and Canadian companies.

[6] One can in principle use other methods to calculate marginal $q$ using only balance sheet data. For example Gilchrist and Himmelberg (1995) and (1998) apply the VAR approach of Abel and Blanchard (1986) to a panel of firms. But in this case the resulting estimate of marginal $q$ is likely to be even more noisy than the average $Q$ calculated using the stock market valuation of firms. Consequently the financing constraints test based on it becomes unreliable.

[7] Among these see Cleary (1999), Gomes (2001), Alti (2003) and Abel and Eberly (2003) and (2004).

[8] Caballero, Engel and Haltiwanger (1995), Eberly, (1997), Barnett and Sakellaris (1998), Doms and Dunne (1998), Abel and Eberly (2002).

capital is subject to non convex adjustment costs, then the $q$ model yields biased estimates, and as a consequence the correlation between fixed investment and internal finance may be positive for financially unconstrained firms, and even larger than that of financially constrained firms.

In this paper we use a different strategy, and we consider a test of financing constraints on firm investment that does not require the estimation of marginal $q$. The idea is that financing imperfections affect not only the investment in durable inputs (fixed capital, such as plant and equipment), but also the investment in nondurable inputs (variable capital, such as materials). The only necessary condition is that there is a time lag between when the input factors are purchased and when the revenues from the goods that have been produced using such factors are received.

In order to develop a formal test of financing constraints based on the investment in variable inputs, we derive a structural model of a firm that uses both fixed and variable capital in the production, and which is subject to financing imperfections. We solve the model and we obtain a reduced form variable investment equation. We demonstrate that under the hypothesis of financing imperfections the financial wealth of the firm is an explanatory variable of this equation, and its coefficient is a measure of the intensity of financing constraints. This approach has two main advantages with respect to the previous literature: i) while fixed investment decisions are forward looking, variable investment decisions are mostly affected by the current productivity shock, which is relatively easy to estimate even if only balance sheet data are available. This means that our financing constraints test does not require the estimation of marginal $q$, and it can be applied also to privately owned firms not quoted on the stock markets; ii) variable investment is less influenced by adjustment costs than fixed investment. This reduces the misspecification problems of the investment equation, and makes it easier to distinguish the contribution of financial factors from the contribution of productivity shocks to the investment decisions of firms.

We verify the validity of this test on a panel of Italian manufacturing firms with 10 years (1982-1991) of balance sheet data. This sample is very useful for the purpose of this paper for two reasons: i) almost all of the firms in the sample are small, and virtually all of them are privately owned and not quoted on the stock market; ii) all the firms in the sample are also covered by an in-depth survey with qualitative information about the financing problems the firms faced in funding investment in the 1989-1991 period. We estimate the variable investment equation on this sample and we confirm the predictions of the model. First, the estimated coefficients do not reject the restrictions imposed by the structural model. Second, the sensitivity of variable investment to internal finance is always significantly positive for firms that are likely to face capital markets imperfections (according to the qualitative survey) while it is not significantly greater than zero for the other firms. The fact that we obtain consistent estimates of the structural parameters of the model is an important property of this test. It implies that we can estimate the intensity of financing constraints for the groups of firms that reject the hypothesis of no financing imperfections. This intensity measures the premium in the cost of external finance with respect to internal finance.

The validity of the financing constraints test adopted in this paper is supported by Caggese (2005), who considers a special case of our model where financing imperfections are in the form of a quantity borrowing constraint. Caggese (2005) solves the investment problem and simulates an industry with many heterogeneous firms. Simulation results show that the sensitivity of variable capital to internal finance is a reliable indicator of the intensity of financing constraints, regardless of the type of adjustment costs of fixed capital, and even if firm investment opportunities are very noisily estimated.

With respect to Caggese (2005) this paper considers a more general financing constraints test which is consistent with several types of financing imperfections that the firms may face. Furthermore the test is able to identify not only the presence but also the intensity of financing constraints. Importantly, the main added value of this paper is to derive a procedure that can be successfully adopted to test the financing constraints hypothesis on a sample of small privately owned firms. With respect to the previous literature, the estimations of this paper show that using small privately owned firms instead of large publicly owned firms allows a more precise estimation of the intensity of financing constraints in an economy.

This paper is organized as follows. Section II reviews the related literature. Section III describes the model. Section IV defines the new financing constraints test. Section V verifies the validity of the new test using the sample of Italian manufacturing firms. Section VI discusses the robustness of the findings and section VII summarizes the conclusions.

## II Related literature

This paper is related to the literature on financing imperfections and the behaviour of small versus large firms. Gertler and Gilchrist (1994), and Bernanke, Gertler and Gilchrist (1998) argue that financing constraints are responsible for the fact that the inventories of small firms decline considerably more than those of large firms at the beginning of a recession. Cabral and Mata (2003) show that the evolution over time of the size distribution of firms is consistent with the presence of financing constraints on small firms. Both papers indicate that financing imperfections of small firms may be important for the economy. With respect to them, the added value of this paper is to develop a formal financing constraints test, based on a structural model of firm behaviour, that can detect both the presence and the intensity of financing constraints on small firms investment.

This paper is also related to the recent literature that explores new ways to test for the presence of financing constraints on firm investment. Among others, Hennessy, Levy and Whited (2005) derive an enhanced version of the $q$ model that allows for the presence of financing frictions and debt overhang. Almeida and Campiello (2005) test the hypothesis that, for a financially constrained firm, the sensitivity of investment to cash flow is increasing in the degree of liquidity of the assets of the firm. Carpenter and Petersen (2003) estimate a version of the $q$ model with cash-flow where the dependent variable is the growth of the total assets of the firm rather than the fixed investment rate. However all of these papers focus on the $q$ model, and as a consequence they cannot be applied to small privately owned firms, which instead is the main contribution of this paper.

Finally, even though our financing constraints test can be applied to any variable factor of production, this paper considers the usage of variable inputs (materials and work in progress) as the dependent variable of the test. Therefore our paper is also related to Kashyap, Lamont and Stein (1994) and Carpenter, Fazzari and Petersen (1994). These authors show that inventories at the firm level are very sensitive to internal finance, especially for those firms a priori more likely to be financially constrained. With respect to these authors, our paper, in addition to proposing a more rigorous financing constraints test that identifies both the presence and the intensity of financing constraints, has other two advantages. First, while the flow of the usage of materials is very close to a frictionless variable input, changes in total inventories are potentially subject to adjustment costs of various nature, such as the presence of fixed costs that imply (S,s) type of inventory policies. Therefore the reduced form linear inventory models estimated by Kashyap, Lamont and Stein (1994) and Carpenter, Fazzari and Petersen (1998) are potentially subject to the same misspecification problem that affects the $q$ model. Second, even if financing constraints affect inventory decisions, this does not necessarily imply that they also affect the investment in production inputs and the level of production of the firm. Indeed the very fact that a financially constrained firm can absorb a reduction in cash flow with a reduction in inventories means that it may be able to maintain the desired flow of variable inputs into the production process. Instead the objective of this paper is precisely to estimate the intensity of financing constraints on the investment in variable inputs and on the production of the firm.

# III The model

This section develops a structural model of investment with financing imperfections and with adjustment costs of fixed capital. We consider a risk neutral firm which has the objective to maximize the discounted sum of future expected dividends. The firm operates with two inputs, $k_t$ and $l_t$, that are respectively fixed and variable capital. The production function is strictly concave in both factors. We assume a Cobb-Douglas functional form:

$$y_t = \theta_t k_t^{\alpha} l_t^{\beta} \text{ with } \alpha > 0, \beta > 0 \text{ and } \alpha + \beta < 1 \tag{1}$$

For simplicity, labour is not considered in the production function and all prices are assumed to be constant and normalized to 1. These simplifying assumptions will be relaxed in the empirical section of the paper. $\theta_t$ is a productivity shock that follows a stationary stochastic process. Variable capital investment is not subject to adjustment costs, while fixed capital investment is subject to adjustment costs $\mu(i_t)$, where $i_t$ is gross fixed investment.

$$i_t = k_t - (1-\delta) k_{t-1} \tag{2}$$

$$\mu(i_t = 0) = 0; \ \mu(i_t \neq 0) \geq 0 \tag{3}$$

We are not more explicit regarding the adjustment costs function $\mu(.)$ because the results derived in this section hold for both concave and convex adjustment costs. $\delta$ is the depreciation rate of fixed capital. For simplicity we assume that variable capital is nondurable, with a 100%

depreciation rate in one period. At time $t$ the firm can borrow from (and lend to) the banks one period debt, with face value $b_t$, at the gross rate $R_t$, receiving the discounted value $\frac{b_t}{R_t}$. A positive (negative) $b_t$ indicates that the firm is a net borrower (lender). Financing imperfections are introduced by assuming that new shares issues are not available, and that $R_t$ increases with the amount borrowed:

**Assumption 1:** *The borrowing rate $R_t$ is determined according to the following rule:*

$$R_t = Rf(b_t) \tag{4}$$

$$\begin{array}{l} f(b_t) = 1 \text{ if } b_t \leq 0 \\ f'(b_t) > 0 \text{ and } f''(b_t) > 0 \text{ if } b_t > 0 \end{array} \tag{5}$$

**Assumption 2**: *We define $\Phi_t$ as follows:*

$$\Phi_t \equiv \frac{\partial (b_t/R_t)}{\partial b_t} = \frac{1}{R_t} - \frac{R}{R_t^2} b_t f'(b_t) \tag{6}$$

*There exists a borrowing level $b^{\max}$, such that $0 \leq b^{\max} < \infty$ and such that $\Phi_t$ evaluated at $b^{\max}$ is equal to zero*:

$$\Phi_t(b^{\max}) = 0 \tag{7}$$

$R = 1+r$, where $r$ is the riskless borrowing/lending rate. Assumption 1 implies that the firm lends at the risk free interest rate $r$ but borrows at an interest rate that monotonously increases with the amount of debt.

Assumption 2 implies that the function $f(b_t)$ is steep enough so that the firm faces a finite borrowing limit $b^{\max}$ (see appendix 1 for a formal proof). $\Phi_t$ measures the increase in $b_t/R_t$ (the funds borrowed in period t) in response to a unitary increase in $b_t$ (the face value of the debt). If $b_t \leq 0$ then $\Phi_t$ is constant and equal to $\frac{1}{R}$. If $b_t > 0$ then $\Phi_t$ decreases as $b_t$ increases, and it becomes negative for $b_t > b^{\max}$.[9]

This upward sloping cost of external finance is consistent with several types of microfoundation of financing imperfections. For example one can assume that the bank can monitor,

[9] A simple functional form that satisfies both assumptions 1 and 2 is the following:

$$f(b_t) = \exp(\xi b_t) \tag{8}$$

Substituting into equation (6) we get:

$$\Phi_t = \frac{1 - b_t \xi}{R \exp(\xi b_t)} \tag{9}$$

In this case the intensity of financing constraints is measured by the parameter $\xi$. The higher is $\xi$, the faster $R_t$ increases as $b_t$ increases, and the lower is $b^{MAX}$.

by paying a cost, the revenues of the firm if this defaults on the debt (Bernanke, Gertler and Gilchrist, 1998). Since the moral hazard of the firm increases with the amount of external debt relative to the amount of internal finance, expected monitoring costs increase with the leverage, and the bank compensates these costs by increasing the interest rates on the loans.

Alternatively one can assume that the firm can hide the revenues from the production. Being unable to observe such revenues the banks can only claim the residual value of the firm's physical assets as repayment of the debt (Hart and Moore, 1998). Therefore if banks are competitive they will only lend collateralized debt demanding a gross interest rate equal to $R$. This type of framework corresponds to assuming that $b^{\max} = 0$ and that the assets of the firm have some collateral value. In section VI,D we will consider an extension of this model that allows part of the debt to be financed with collateral, and we will show that this does not change the predictions of the model nor the interpretation of the results obtained in the empirical section of the paper. The timing of the model is the following:

| Beginning of period $t$ | | | End of period $t$ |
|---|---|---|---|
| $\theta_t$ is realised | the firm repays $b_{t-1}$,<br>$w_t$ is total net worth | the firm borrows $b_t$,<br>and decides $d_t$, $k_t$ and $l_t$ | $y_t$ is produced |

At the beginning of period $t$ the firm has a stock of already installed fixed capital equal to $(1-\delta)\,k_{t-1}$. It observes the productivity shock $\theta_t$, repays the face value of the debt $b_{t-1}$, and decides how much to borrow, to invest, and to pay out in dividends. It is useful to define the net worth of the firm $w_t$, after the debt $b_{t-1}$ is repaid, as follows:

$$w_t = w_t^F + (1-\delta_k)k_{t-1} \tag{10}$$

Where $w_t^F$ is financial wealth:

$$w_t^F = y_{t-1} - b_{t-1} \tag{11}$$

Using equations (2), (10) and (11) we define the budget constraint as follows:

$$d_t + l_t + i_t + \mu\,(i_t) = w_t^F + \frac{b_t}{R_t} \tag{12}$$

$$d_t \geq 0 \tag{13}$$

Equation (13) states that dividends $d_t$ cannot be negative. Production takes place during the period, and at the end of period $t$ the firm obtains revenues $y_t$. Equation (12) together with conditions (4)-(6) implies that the firm is insolvent at the beginning of period $t$ if it is not able to repay the existing debt, even by investing the minimum possible and borrowing to the limit. In order to simplify the analysis we make the following assumption that rules out insolvency:

**Assumption 3:** *the stochastic process for the productivity shock, the shape of the adjustment cost function $\mu(i_t)$, and the value of the parameters $\alpha, \beta, \delta$, $R$, $w_0$ and $k_0$ are such that the following condition is always satisfied in equilibrium:*

$$w_t^F + \frac{b^{\max}}{Rf\left(b^{\max}\right)} \geq \min_{i_t}\left[i_t + \mu\left(i_t\right)\right] \tag{14}$$

The right hand side of equation (14) is the minimum level of investment in the firm that does not violate condition (3). In the absence of adjustment costs the firm could sell all the fixed capital, and the minimum level of investment would be equal to $-(1-\delta)k_t$. Allowing insolvency to happen with positive probability would make the analysis more complicated but would not change the implications of the model for the empirical test of financing constraints. Moreover, as argued above, the assumptions 1 and 2 about the interest rate function $R_t$ can be interpreted as a shortcut for more complex types of bank-firm relationships where the financing constraints arise because of the costly verification of the assets of the firm when this defaults on the debt.[10]

Let's denote the value at time $t$ of the firm, after having observed $\theta_t$, by $V_t\left(w_t, \theta_t, k_{t-1}\right)$ :

$$V_t\left(w_t, \theta_t, k_{t-1}\right) = \max_{k_t, b_t, l_t} d_t + \frac{1}{R}E_t\left[V_{t+1}\left(w_{t+1}, \theta_{t+1}, k_t\right)\right] \tag{15}$$

The firm maximizes (15) subject to constraints (12) and (13). $R$ is the relevant discount factor because the firm can lend at the market gross interest rate $R$, and because of the no insolvency condition (14). For a large class of adjustment cost functions $\mu(.)$ these constraints define a compact and convex feasibility set for $l_t$, $k_t$, $b_t$ and $d_t$, and the law of motion of $w_{t+1}$ conditional on $w_t, k_{t-1}$ and $\theta_t$ is continuous. Therefore, given the assumptions on $\theta_t$ and the concavity of the production function, a unique solution to the problem exists. In order to describe the optimality

[10] Of course in reality the debt of a firm may be risky, and changes in its riskyness may change the cost of capital for reasons unrelated to the presence of financing constraints. In section V we will show that this is not likely to affect the validity of the financing constraints test developed in this paper and estimated in the following sections.

conditions of the model, we use the budget constraint (12) in order to substitute $d_t$ in the value function (15). Moreover in the following analysis we assume that the marginal adjustment cost function $\mu'(i_t)$ is continuous and smooth in $i_t$. In appendix 2 we illustrate the solution of the model when this assumption is relaxed. Let $\phi_t$ be the Lagrangian multiplier associated with the dividend constraint (13). The first order conditions with respect to $b_t, l_t$ and $k_t$ are respectively equations (16), (17) and (18):

$$(1+\phi_t)\,\Phi_t - \frac{1}{R}E_t\left[\frac{\partial V_{t+1}(w_{t+1},\theta_{t+1},k_t)}{\partial w_{t+1}}\right]=0 \tag{16}$$

$$-(1+\phi_t)+\frac{1}{R}\left[\frac{\partial E_t\left[V_{t+1}(w_{t+1},\theta_{t+1},k_t)\right]}{\partial w_{t+1}}\beta\theta_t k_t^{\alpha} l_t^{\beta-1}\right]=0 \tag{17}$$

$$-(1+\phi_t)(1+\mu_t')+\frac{1}{R}\left[\frac{\partial E_t\left[V_{t+1}(w_t,\theta_{t+1},k_t)\right]}{\partial k_t}+\frac{\partial E_t\left[V_{t+1}(w_t,\theta_{t+1},k_t)\right]}{\partial w_t}\left(\alpha\theta_t k_t^{\alpha-1}l_t^{\beta}+1-\delta_k\right)\right]=0 \tag{18}$$

Using the fact that $\frac{\partial V_t(w_t,\theta_t,k_{t-1})}{\partial w_t}=1+\phi_t$, equation (16) can be rearranged as follows:

$$\phi_t = RE_t\left[\sum_{j=0}^{\infty}\left(\prod_{k=0}^{j}\frac{1}{R\Phi_{t+k}}\right)\left(\frac{1}{R}-\Phi_{t+k}\right)\right] \tag{19}$$

$1+\phi_t$ is the shadow value of one additional unit of internal finance. We define $w_t^{\max}\left(\theta_t, w_t^F, k_{t-1}\right)$ as the level of financial wealth that allows to finance all investment without borrowing (see appendix 3 for details), and we distinguish three regimes: regime A: $w_t^F < w_t^{\max}$ and $b_t > 0$. In this case $\phi_t > 0$ because the cost of capital in period $t$ is higher than $R$. The firm uses earnings to lower its debt and sets $d_t = 0$. Regime B: $w_t^{\max} \leq w_t^F < \overline{w}_t$ , where $\overline{w}_t$ is the level of wealth that guarantees no financing constraints now and in the future. In this case $b_t \leq 0$, but $pr\,(b_{t+j} > 0) > 0$ for some $j > 0$. The cost of capital in period $t$ is equal to $R$, but $\phi_t > 0$ because the firm may need to borrow in the future. The firm sets $d_t = 0$ and retains all earnings for precautionary reasons. Regime C: $w_t^F \geq \overline{w}_t$. The firm is so wealthy that $pr(b_{t+j} > 0) = 0$ for all $j \geq 0$. In this case $\Phi_{t+j} = \frac{1}{R}$ for all $j \geq 0$ and $\phi_t = 0$. The firm is indifferent between retaining and distributing earnings.

# IV Adjustment costs, financial frictions and investment

Financial wealth affects variable investment decisions only in regime A, when $b_t > 0$. In this case an increase in $w_t^F$ reduce $b_t$ and the cost of capital $R_t$. This means that, for a given productivity level $\theta_t$ the firm invests more if it has more internal finance available. In order to translate this intuition in a formal financing constraints test we use equation (16) to substitute $\frac{\partial E_t[V_{t+1}(w_t,\theta_{t+1},k_t)]}{\partial w_t}$ in equation (18). Then we use the fact that $\frac{\partial E_t[V_{t+1}(w_t,\theta_{t+1},k_t)]}{\partial k_t} = (1-\delta) E_t\left[(1+\phi_t)\mu'_{t+1}\right]$ to derive the following:

$$\alpha\theta_t k_t^{\alpha-1} l_t^{\beta} = UC_t - (1-\delta) + UC_t\left\{\mu'_t - \frac{(1-\delta)E_t\left[(1+\phi_{t+1})\mu'_{t+1}\right]}{R(1+\phi_t)}\right\} \tag{20}$$

It is also possible to derive an analogous expression for variable capital:

$$\beta\theta_t k_t^{\alpha} l_t^{\beta-1} = UC_t \tag{21}$$

Where $UC_t$ is the user cost of capital:

$$UC_t \equiv \frac{1}{\Phi_t} \tag{22}$$

Assumptions 1 and 2 imply that $UC_t = R$ if $b_t \leq 0$, that $\frac{\partial UC_t}{\partial b_t} > 0$ and $\frac{\partial^2 UC_t}{\partial b_t^2} > 0$ if $b_t > 0$ and that at the limit:

$$\lim_{b_t \to b^{\max}} UC_t = \infty \tag{23}$$

Equation (20) represents the optimality condition for the fixed capital level $k_t$. The left hand side is the marginal productivity of fixed capital, and the right hand side the marginal cost of fixed capital. The term $UC_t - (1-\delta)$ is the marginal financial cost of buying one additional unit of fixed capital net of the residual value $(1-\delta)$. The last term on the right hand side measures the net marginal adjustment costs of capital. Future expected marginal adjustment costs $\mu'_{t+1}$ are multiplied by the shadow value of money $(1+\phi_{t+1})$. If the firm expects to be more financially constrained in the future, then $E_t(\phi_{t+1})$ is higher (see equation 19), and this increases the cost of adjusting fixed capital in the future.

Equation (21) represents the optimality condition for the variable capital level $l_t$. The key property of variable capital is that it is not directly affected by the adjustment cost function $\mu_t$, nor by future expected financing constraints $E_t(\phi_{t+1})$. The financing constraints test developed in this paper uses this property plus the fact that the intensity of financing constraints is a monotonous function of $w_{i,t}^F$, as stated in the following proposition:

**Proposition 1** *For a given value of the state variables $\theta_t$ and $k_{t-1}$, and for $w_t^F < w_t^{\max}$, then $b_t > 0$ and the user cost of capital is decreasing and convex in the amount of internal finance:*

$$\frac{\partial UC_t}{\partial w_t^F} < 0 \ , \ \frac{\partial^2 UC_t}{\partial \left(w_t^F\right)^2} > 0 \ \textit{and} \lim_{w_t^F \to w_t^{MAX}} UC_t = R$$

*Conversely if $w_t^F \geq w_t^{\max}$ then $b_t \leq 0$, $UC_t = R$ and $\frac{\partial UC_t}{\partial w_t^F} = 0$*

***Corollary 2*** *conditional on $\theta_t$ and $w_t^F$, $w_t^{\max}$ is a monotonously decreasing function of $k_{t-1}$*

Proof: see appendix 3.

Proposition 1 establishes a link between financing imperfections and the real investment decisions of firms. It says that when a firm is financially constrained then the availability of internal finance reduces the marginal cost of capital. Corollary 2 simply states that the amount of financial wealth needed to finance investment is a decreasing function of the stock of non financial wealth.

We use proposition 1 and equation (21) to derive a financing constraints test based on variable capital. Equation (21) implies that, conditional on $k_t$ and $\theta_t$ there is a direct relationship between variable investment $l_t$ and $UC_t$. Proposition 1 allows to substitute $UC_t$ with a function of $w_t^F$. Instead proposition 1 is not useful to test financing constraints on fixed capital investment, due to the presence of the adjustment costs function $\mu_t$. The previous literature avoids this problem by assuming that $\mu_t$ is symmetric and quadratic in $i_t$:

$$\mu_t = \frac{a}{2} i_t^2 \implies \mu_t' = a i_t$$

In this case it is possible to rearrange equation (20) as follows:

$$i_t = \frac{1}{a} MPK_t + \frac{(1-\delta)}{R} E_t \left[ \frac{1+\phi_{t+1}}{1+\phi_t} i_{t+1} \right] \tag{24}$$

Where $MPK_t$ is the value of the marginal profits from the investment in fixed capital, discounted using the marginal cost of capital for the firm:

$$MPK_t \equiv \Phi_t \left[ \alpha \theta_t k_t^{\alpha-1} l_t^{\beta} + (1-\delta_k) \right] - 1 \tag{25}$$

If the firm is not subject to financing imperfection, then $MPK_t = \frac{\left[\alpha\theta_t k_t^{\alpha-1} l_t^{\beta} + (1-\delta_k)\right]}{R} - 1$, which is the value of marginal profits discounted at the market interest rate. Moreover $\frac{1+\phi_{t+1}}{1+\phi_t} = 1$, and equation (24) can be solved recursively forward to obtain the $q-$model, where investment is a linear function of Tobin's marginal $q$:

$$i_t = \frac{1}{Ra}\left(q_t - 1\right) \tag{26}$$

Following Fazzari, Hubbard and Petersen (1988), several authors verify the presence of financing constraints on firm investment by adding cash flow to the right hand side of the $q$ model. Under the assumption of quadratic adjustment costs, equations (24), (25) and (26) support the validity of this procedure. If the firm is financially constrained then an increase in cash flow reduces the cost of borrowing and increases investment for a given value of $q_t$.

Beside the limits of this approach already mentioned in the introduction, the main problem is that the $q-$model virtually excludes from the analysis the small privately owned firms for which the market valuation of the assets is not normally available. Another estimation strategy, alternative to the $q-$model, is to solve equation (24) backwards, and estimate an Euler equation with the investment rate as dependent variable and lagged investment rate, lagged output and lagged cash flow among the regressors (Bond and Meghir, 1994). But as it is the case with the $q$ model, also this approach relies on the assumption that adjustment costs are quadratic. We argued before that this assumption is not realistic, because a large empirical literature shows that fixed costs and irreversibility are important for the decision to invest in fixed capital.[11] Therefore the Euler equation is misspecified, and its estimation becomes useless in identifying the effect of financing constraints on firm investment.

In this paper we propose a different approach and we design a financing constraints test that takes advantage of proposition 1. If we take logs of both sides of equation (21), we obtain the following:

$$\ln\beta + \ln\left(\theta_t\right) + \alpha\ln k_t + (\beta - 1)\ln l_t = \ln UC_t \tag{27}$$

By solving for $\ln l_t$ we obtain:

$$\ln l_t = \frac{\ln\left(\beta\right)}{1-\beta} + \frac{1}{1-\beta}\ln\theta_t + \frac{\alpha}{1-\beta}\ln k_t - \frac{1}{1-\beta}\ln UC_t \tag{28}$$

[11] See footnote n.8

Proposition 1 allows us to substitute $\ln UC_t$ with a negative and convex function of $w_t^F$. Therefore:

$$\ln l_t = \pi_0 + \pi_1 \ln \theta_t + \pi_2 \ln k_t + \pi_3 f\left(w_t^F\right) \tag{29}$$

Where:

$$\pi_0 = \frac{\ln(\beta)}{1-\beta};\ \pi_1 = \frac{1}{1-\beta};\ \pi_2 = \frac{\alpha}{1-\beta};\ \pi_3 = \frac{1}{1-\beta};\ f'\left(w_t^F\right) > 0;\ f''\left(w_t^F\right) < 0 \tag{30}$$

The financing constraints hypothesis predicts that $\pi_3$ is positive if the firm is financially constrained and is equal to zero otherwise. Moreover we can estimate a parametric approximation of the function $f(.)$, and we can obtain a measure of the intensity of financing constraints. The main advantage of this test is that, because it does not rely on marginal $q$, it can be easily applied to datasets of small firms for which only balance sheet data are available. But this test has also two additional advantages: i) future expected financing problems and adjustment costs of fixed capital do not affect the test results, because their effect is entirely captured by the level of fixed capital $k_t$; ii) the effect of productivity on variable capital investment is summarized by $\theta_t$. This term only depends on the current productivity shock, and therefore it can be estimated using only balance sheet data.

## A Alternative testing strategies

Equation (29) is not the only possible formulation of a financing constraints test based on proposition 1, but is the one that we found better suited to be applied to the data. For example it is possible to use a function of $b_t$ instead than of $w_t^F$ as the variable that measures the intensity of financing constraints in equation (29). Assumptions 1 and 2 imply that in this case we expect the coefficient of $b_t$ to be negative in case of financing constraints and zero otherwise. However one problem with this approach is that it is more difficult to determine $b_t$ than $w_t^F$. This is because in the model all debt is short term, while in reality the maturity of the debt of the firm is very variable, and it is difficult to estimate which fraction of the total debt is relevant for the financing of variable capital. Moreover $w_t^F$ is a predetermined variable, while $b_t$ is chosen simultaneously with $l_t$. This increases the difficulty to obtain consistent estimates of the parameters of equation (29).

Finally, one could transform equation (21) as follows:

$$\beta \frac{y_t}{l_t} = UC_t \tag{31}$$

And then derive the following equation:

$$\ln l_t = \pi_0 + \pi_1 \ln y_t + \pi_2 f\left(w_t^F\right) \tag{32}$$

From the point of view of our theoretical model equations (29) and (32) are equivalent because $y_{i,t}$ depends on $\theta_{i,t}$, which is the beginning of the period $t$ productivity shock. In estimating equation (29) we maintain this interpretation of $\theta_{i,t}$, because we estimate it using only information up to the end of period $t-1$. Instead if we estimate equation (32) we face the problem that in the data $y_t$ is the flow of output during period $t$, and it includes the productivity shocks that are realized after $l_t$ is decided. Because these shocks are surely strongly correlated to the error in the estimation of equation (32), we would have an endogeneity problem very difficult to eliminate.

# V Empirical evidence

In this section we verify empirically the validity of our test of financing constraints on a sample of small and medium Italian manufacturing firms. The sample is obtained by merging the two following datasets: i) a balanced panel of more than 5000 firms with company accounts data for the 1982-1991 period.[12] This is drawn from the broader dataset of the Company Accounts Data Service, which is the most reliable source of information on the balance sheet and income statements of Italian firms. The dataset includes around 30000 Italian non financial firms, and it has been often used in empirical studies on firm investment (e.g. Guiso and Parigi, 1999). ii) The first Mediocredito Centrale Survey on small and medium Italian manufacturing firms, which provides a wide range of qualitative information about the activity of a randomly chosen sample of more than 4400 firms in the 1989-1991 period.[13] In particular the Mediocredito Survey asks if the firms had any of the following problems regarding the financing of new investment projects in the 1989-91 period: a) lack of medium-long term financing; b) too high cost of banking debt; c) lack of guarantees.

[12] The original sample had balance sheet data from 1982 to 1994, but we discarded the last three years of balance sheet data (1992, 1993 and 1994) from the sample, because of discrepancies and discontinuities in some of the balance sheet items, probably due to changes in accounting rules in Italy in 1992.

[13] Examples of published papers that use the Mediocredito Centrale survey are Basile, Giunta and Nugent (2003) and Piga (2002).

The merged sample is composed of 812 firms. From this sample we eliminate firms without the detailed information about the composition of fixed assets (do not distinguish between plant and equipment on the one side and land and building on the other side), remaining with 561 firms. We further eliminate firms that merged with other firms or firms that split in the sample period. The remaining sample is composed of 415 firms, virtually none of which is quoted on the stock markets. The percentage of positive answers to the questions about financing problems for this subsample are respectively 13.2% for question (a), 13.7% for question (b) and 2% for question (c). In total 22.2% of the firms stated any of the three problems.

It is worthwhile noting that the selection of the firms in this sample is biased towards less financially constrained firms, for at least two reasons: i) the prerequisite to be in the dataset is to have been continually in operation between 1982 and 1994. Therefore the sample excludes new firms and firms that exited during the same period because of financial difficulties; ii) by eliminating mergers we eliminate firms in profitable businesses that merged with other companies because of their financing problems.

For the empirical specification of the financing constraints test we consider the following production function:

$$y_{i,t} = \theta_{i,t} k_{i,t-1}^{\alpha} l_{i,t}^{\beta} n_{i,t}^{\gamma} \tag{33}$$

All variables are in real terms, and are the following:

- $y_{i,t}$ = total revenues (end of period $t$, firm i)
- $k_{i,t-1}$ = replacement value of plant, equipment and intangible fixed capital (end of period $t-1$, firm i)
- $l_{i,t}$ = cost of the usage of materials (during period t, firm $i$)
- $n_{i,t}$ = labour cost (during period t, firm $i$)

Detailed information about all the variables is reported in appendix 5. With respect to the theoretical model, equation (33) includes labour as a factor of production and it includes fixed capital as lagged by one period. Therefore we assume that fixed capital installed in period $t$ will become productive from period $t+1$ on. In appendix 4 we derive the solution of the optimization problem under these assumption, and we show that proposition 1 still holds, and that the reduced form variable capital equation takes the following form:

$$\ln l_{i,t} = \frac{\ln(\beta)}{1-\beta} + \frac{1}{1-\beta}\ln\theta_{i,t} + \frac{\alpha}{1-\beta}\ln k_{i,t-1} + \frac{\gamma}{1-\beta}\ln n_{i,t} - \frac{1}{1-\beta}\ln UC_t \tag{34}$$

Proposition 1 shows that, conditional on $w_t^F$ being smaller than $w_t^{\max}$, $UC_t$ is a decreasing and convex function of $w_t^F$. This relationship can be formalized by the following functional form:

$$\begin{aligned} UC_t &= R(w_t^{\max}/w_t^F)^\eta \text{ if } w_t^F \leq w_t^{\max} \\ UC_t &= R \text{ if } w_t^F > w_t^{\max} \end{aligned}$$

Because in reality firms do not accumulate financial wealth much above $w_t^{\max}$, we can approximate this function simply with $UC_t = R(w_t^{\max}/w_t)^\eta$. By substituting it in equation (34), we obtain:

$$\ln l_{i,t} = \frac{\ln(\beta)}{1-\beta} + \frac{1}{1-\beta}\ln\theta_{i,t} + \frac{\alpha}{1-\beta}\ln k_{i,t-1} + \frac{\gamma}{1-\beta}\ln n_{i,t} + \frac{\eta}{1-\beta}\ln w_{i,t}^F - \frac{\eta}{1-\beta}\ln w_{i,t}^{\max} \tag{35}$$

Moreover corollary 2 implies that, conditional on $\theta_{i,t}$and $w_{i,t}^F$, $w_{i,t}^{\max}$ decreases in $k_{i,t-1}$, because the larger is the amount of non financial wealth, the smaller is the amount of financial wealth needed to finance investment without borrowing. Therefore we can approximate it as follows:

$$\ln w_{i,t}^{\max} = \ln \frac{b_i}{k_{i,t-1}^{\kappa}} \tag{36}$$

$b_i$ is assumed to be a firm specific variable. By using equation (36) in equation (35) and by adding firm and year dummy variables and an error term, we obtain the following equation:

$$\ln l_{i,t} = a_i + d_t + \pi_1 \ln\theta_{i,t} + \pi_2 \ln k_{i,t-1} + \pi_3 \ln n_{i,t} + \pi_4 \ln w_{i,t}^F + \varepsilon_{i,t} \tag{37}$$

Where.

$$\pi_1 = \frac{1}{1-\beta};\ \pi_2 = \frac{\alpha+\eta\kappa}{1-\beta};\ \pi_3 = \frac{\gamma}{1-\beta}; \pi_4 = \frac{\eta}{1-\beta} \tag{38}$$

The sensitivity of $\ln l_{i,t}$ to $\ln w_{i,t}^F$ is proportional to the parameter $\eta$, which measures the intensity of financing constraints. The larger is $\eta$, the faster $R_t$ and $UC_t$ increase as $w_t^F$ decreases below $w_t^{\max}$. The reduced form parameters $\pi_1, \pi_2$ and $\pi_4$ can be used to recover the structural parameters $\beta, \gamma$ and $\eta$. Moreover conditional on finding that $\eta$ is not significantly different from zero, $\pi_2$ can be used to recover the parameter $\alpha$. In any case as both $\eta$ and $\kappa$ are expected to be small, the coefficient $\pi_2$ should not be significantly different across constrained and unconstrained firms.

One shortcoming of equation (37) is that in the theoretical model we assume that in the absence of financing constraints the user cost of variable capital is constant and equal to $R$. In reality the user cost of capital may vary across firms and over time for several reasons unrelated to financing imperfections, like transaction costs, taxes, and risk. Therefore in equation (37) we also include firm and year dummy variables, respectively $a_i$ and $d_t$. These capture, among other things, the coefficient $b_i$ in equation (36) and the changes in the user cost of capital across firms and over time for all the firms. In section VI we will discuss the robustness of the results to intra-firms unobservable changes in the user cost of capital not related to financing constraints.

$\varepsilon_{i,t}$ is the error term. $\ln \theta_{i,t}$ is the beginning of the period $t$ productivity shock. It is estimated from the Solow residual of the production function, using information up to the end of period $t-1$. The method used is robust to the presence of decreasing returns to scale and to heterogeneity in technology, because we estimate the factor elasticities to output directly from the production function, and separately for groups of firms in different sectors. Detailed information about the procedure used is in appendix 6. Financial wealth $w_{i,t}^F$ is the following:

$w_{i,t}^F$ = liquidity at the end of period $t-1$ plus net short term credit (net credit that expires before the end of time $t$. Both banking and commercial debt and credit are included in the computation) plus the stock of finished goods inventories at the end of period $t-1$.

The variable $w_{i,t}^F$ represents an estimate of the amount of internal finance available for investing in period $t$. It includes the stock of finished goods inventories available at the end of period $t-1$, because most of such goods will be transformed in cash flow before the end of period $t$. Since wealth is introduced as a concave transformation, the variable $\ln w_{i,t}^F$ cannot be computed for the 18% of the firm-year observations that have a negative value of $w_{i,t}^F$. In section VI,B we propose a normalization method to take care of this problem, as well as an alternative measure of financial wealth that does not include finished goods inventories.

The estimation of equation (37) is complicated by the endogeneity of the regressors. $\ln n_{i,t}$ is endogenous because it is simultaneously determined with $\ln l_{i,t}$. But also the other right hand side variables may be endogenous and correlated to $\varepsilon_{i,t}$. This happens if the term $\ln \theta_{i,t}$ does not capture entirely the unobservable productivity shock. Moreover the regressors are also most likely correlated with the firm specific effect $a_i$. In this case a suitable estimation strategy is to first difference equation (37) to eliminate the unobservable firm specific effect $a_i$, and then estimate it with a GMM estimation technique, using the available lagged levels of the explanatory variables as instruments for their first differences. In this case the set of instruments is different for each year, and equation (37) is estimated as a system of cross sectional equations, each one corresponding to a different period $t$ (Arellano and Bond, 1991). More recent lags are likely to be better instruments, but they may be correlated with the error term if this is itself autocorrelated. The test of overidentifying restrictions can be used to assess the orthogonality of the instruments with the error term. Moreover, under the assumption that $E\left(\Delta z_{i,t-j}, a_i\right) = 0$, with $z = \left\{\ln\theta_{i,t}, \ln k_{i,t}, \ln w_{i,t}^F, \ln n_{i,t}\right\}$, $\Delta z_{i,t-j}$ are valid instrument for equation (37) estimated in levels. Blundell and Bond (1998) propose a SYSTEM GMM estimation technique that uses both the equation in level (instrumented using lagged first differences), and the equation in first differences (instrumented using lagged levels). They show, with Monte Carlo simulations, that the SYSTEM GMM estimator is much more efficient than the simple GMM estimator when the regressors are highly persistent, and when the number of observations is small. These properties are particularly useful in our context.

The primary objective of this empirical analysis is to verify that the coefficient of $\ln w_{i,t}^F$ in equation (37) is a precise indicator of the intensity of financing constraints. We do it by using the direct information provided by the Mediocredito Survey. This information allows us to select a subsample of firms that are more likely to be financially constrained, and to estimate equation (37) for these firms. Our new financing constraints test works if the coefficient of $\ln w_{i,t}^F$ is found to be significantly higher for firms more likely to face financing imperfections (based on the information on the Mediocredito Survey) than for the other firms. In this respect the most useful information present in the Survey is the question about the problem in financing new investment projects because of “too high cost of banking debt”. Given that banking debt is the main source of external finance for the firms in the sample, this information is strongly related to the definition of financing constraints employed in the model. We also select firms according to the information about the problem of “lack of medium/long term financing”, as well as to some exogenous criteria commonly used in the previous literature as indicators of financing imperfections:[14] i) dividend policy: firms that have higher cost (or rationing) of external finance than of internally generated finance are less likely to distribute dividends. Therefore the observed dividend policy should be correlated to the intensity of financing constraints. ii) Size and age: smaller and younger firms usually are more subject to informational asymmetries that may generate financing constraints.

More specifically, we estimate equation (37) for subsamples of firms selected according to the following criteria, where the dummy variable $D_{i,t}^{x}$ is equal to 1 if the firm $i$ belong to the specific group $x$ and zero otherwise.

Direct criteria:

- $D^{hs}$ : too high cost of banking debt (13.7% of all firms).
- $D^{lc}$ : lack of medium long term financing (13.2% of all firms).

Indirect criteria:

- $D^{age}$ :age: founded after 1979 (16% of all firms).
- $D^{divpol}$ :dividend policy: zero dividends in any period (33.4% of all firms).
- $D^{size}$ :size: less than 65 employees (in 1992) (16% of all firms).

We estimate the coefficients of equation (37) separately for each group of firms and for the complementary sample, by interacting the explanatory variables with the dummy variables. The qualitative survey was conducted in 1992 and the firms were asked about their problems in financing investment in the 1989-91 period. Therefore one obvious problem with including the dummies $D^{hs}$ and $D^{lc}$ in the regression is that these are endogenous. In order solve this problem we use instrumental variables. We run two discriminant regressions where $D^{hs}$ and $D^{lc}$ are the dependent variables. The regressors are the average size of the firm (before 1989), and a set of explanatory variables dated from 1986 to 1988: net income margin (net income over total sales), net sales growth, ratio between long term debt and fixed assets, ratio between short term debt and fixed assets, estimated productivity shock.

[14] We do not select firms according to the question about "lack of guarantees", because only 2% of firms stated it as a problem in financing investment.

The result of the discriminant analysis shows that the discriminant score successfully predicts 71% of the $D^{hs} = 1$ observations and 63% of the $D^{hs} = 0$ observations. The predictive power is a bit lower for $D^{lc} = 1$ and $D^{lc} = 0$, with respectively 67% and 62%. We use the estimated coefficients to compute the discriminant score, which can be interpreted as the likelihood that the firms were financially constrained in the 1989-91 period, and we call $\widehat{D}_i^{hs}$ and $\widehat{D}_i^{lc}$ two dummy variables that have value one if the discriminant score is higher than a certain threshold for firm $i$, and zero otherwise. The threshold is chosen so that $\widehat{D}^{hs}$ and $\widehat{D}^{lc}$ have approximately the same fraction of ones than the $D^{hs}$ and $D^{lc}$ dummies. Since all the variables used for the discriminant analysis are available since 1983, we can also use the estimated discriminant coefficients to calculate the likelihood that the firms where financially constrained in the 1986-88 period. We combine the information of this score and the 1989-91 score to create $\widehat{D}^{hs}-panel$ and $\widehat{D}^{lc}-panel$, which are equal to one in the periods in which the firm was likely financially constrained (i.e. had the score higher than a certain threshold) and equal to zero otherwise. Also in this case the thresholds are chosen so that the percentage of likely constrained firms is analogous to the fraction of ones in the $D^{hc}$ and $D^{lc}$ dummies. Table I shows the summary statistics for the whole sample and for the subgroups of likely financially constrained firms. The whole sample is composed almost entirely by small firms. 50% of the firms are under 123 employees and 90% are under 433 employees. Virtually all of these firms are privately owned and not quoted on the stock market. Likely financially constrained firms do not show significant differences with respect to the other firms in terms of size, growth rate of sales, investment rates and riskiness (volatility of output). The most noticeable differences regard the financial structure. Firms that declare financing constraints are less wealthy and on average pay higher interest rates on banking debt. This explains why, even though their average gross income margin (income before financial costs and revenues divided by total sales) is the same as for the other firms, their average net income margin is lower. Even though all these differences are small, they are fully consistent with the predictions of our theoretical model.

Table II shows the estimates of equation (37) for the whole sample and for the groups selected according to the "direct criteria" dummies $\widehat{D}^{hs}$ and $\widehat{D}^{lc}$. In the first column we use the data from the 1986-91 period, for which we have available the full set of instruments. In the other columns we estimate the model for the shorter 1988-91 period.[15]

The full sample estimates in the first two columns show that the coefficients of $\ln \theta_{i,t}$, $\ln k_{i,t-1}$ and $\ln n_{i,t}$ are all significant and all have the expected sign and size. The coefficient of $\ln w_{i,t}^F$ is small in magnitude, negative, and not significantly different from zero for the 1986-91 period. This suggests that financing constraints do not affect a large share of firms in the sample, and is consistent with the information from the Mediocredito survey, where only 22% of the firms state problems in financing investment. The fact that the estimated coefficient of $\ln w_{i,t}^F$ is very small allows us to approximate $\eta\kappa$ to zero for the whole sample. Then using the restrictions in equation (38) we can calculate the structural parameters $\alpha, \beta$ and $\gamma$, which are the elasticities of output with respect to the inputs. They are reported in table III. The estimates of $\alpha, \beta$ and $\gamma$ are consistent with the values directly estimated from the production function. In appendix 6 we estimate the production function for the different sectors and we find $\widehat{\alpha}$ to be between 0.04 and 0.19, $\widehat{\beta}$ to be between 0.29 and 0.56 and $\widehat{\gamma}$ to be between 0.19 and 0.49. Similar value of $\widehat{\beta}$ and $\widehat{\gamma}$ are also found by Hall and Mairesse (1996), who estimate a production function including the cost of material inputs. Moreover the estimates of $\alpha$, $\beta$ and $\gamma$ are also remarkably consistent with the simple calculation of the elasticities using the factors shares of output, which are reported at the bottom of table III. The fact that the restrictions imposed by the structural model on the coefficients of $\ln \theta_{i,t}$, $\ln k_{i,t-1}$ and $\ln n_{i,t}$ are not rejected by the estimation results is important, because it confirms the validity of our structural model.

The third and fourth columns in table II allow all the coefficients to vary across the subgroups of firms. In column 3 the first set of coefficients are relative to the group of firms predicted not to declare the problem of too high cost of debt ($\widehat{D}^{hs} = 0$). The second set of coefficients are relative to all the regressors multiplied by $\widehat{D}^{hs}$. They represent the difference between the coefficient for the likely constrained firms ($\widehat{D}^{hs} = 1$) and that of the complementary sample ($\widehat{D}^{hs} = 0$).[16] Therefore the $t$-statistic of this second set of estimates can be used to test the equality of the coefficients across groups. The results show that the coefficient of $\ln w_{i,t}^F$ is positive, large in absolute value, and strongly significant for the likely constrained firms, and negative and not significantly different from zero the likely unconstrained firms. This result confirms the presence

[15] We restrict the sample because the Mediocredito Survey refers to the 1989-91 period. We include also 1988 to increase the time dimension of the sample, on the ground that the qualitative answers of the firms may not be exactly limited to the three years indicated in the survey.

[16] Also the constant, the yearly dummies, and all the instruments are interacted with $\widehat{D}^{hc}$.

of financing constraints on the investment decisions of the firms that are predicted to declare the problem of too high cost of debt in financing new investment projects. Importantly, the estimated coefficients of capital and labour differ very little across the two groups of firms. Only the coefficient of $\ln \theta_{i,t}$ has a large difference across groups. But this difference has a very large standard error, and is not significantly different from zero at the 10% significance level. By using the estimate of $\widehat{\beta} = 0.64$ obtained before, the estimated $\widehat{\eta}$ is equal to 0.15 for the constrained firms ($\widehat{D}^{hs} = 1$). This implies that if $w_t^F$ is 80% of $w_t^{MAX}$, then the marginal user cost of variable capital is 3.4% higher with respect to the cost of financing variable capital with internal finance. This percentage increases to 11% if $w_t^F$ is 50% of $w_t^{MAX}$.

The fourth column reports the results of the estimations with $\widehat{D}^{ls} = 1$ as the criterion to select likely financially constrained firms. Also in this case the coefficient of $\ln w_{i,t}^F$ is significantly higher for the $\widehat{D}^{ls} = 1$ firms than for the $\widehat{D}^{ls} = 0$ firms, and the other coefficients are not different across groups with the exception of the coefficient of $\ln n_{i,t}$. In table IV we estimate equation (37) for the 1986-91 sample, and we allow the coefficients to vary for the groups identified by the indirect criteria $D^{age}$, $D^{divpol}$ and $D^{size}$ and by $\widehat{D}^{hs} - panel$ and $\widehat{D}^{lc} - panel$. The coefficient of $\ln w_{i,t}^F$ is always very small, and always not significantly different from zero for the likely unconstrained firms, while is significantly positive for all the groups of likely constrained firms except the $D^{divpol} = 1$ group.

# VI Robustness checks

Tables II and IV show that the sensitivity of variable capital investment to internal finance is a useful indicator of the intensity of financing constraints. Several considerations indicate that this result is robust to possible misspecification problems. First, the claim that equation (37) is correctly specified is confirmed by the fact that the estimates do not reject the restrictions imposed by the structural parameters of the model.

Second, our findings are robust to the criticisms that Kaplan and Zingales (1997) and other authors formulated against the correlation between fixed investment and cash flow as a good measure of the intensity of financing constraints. The most important of these criticisms is that cash flow may be significant in an investment equation only because it captures the effect of the unobservable productivity shock. In other words, a firm that has a positive productivity shock simultaneously generates a lot of revenues and cash flow and invests a lot. Using the same reasoning here, one could argue that the coefficient of $\ln w_{i,t}^F$ is positive not when the firm is financially constrained, but when it is a productive and fast growing firm that at the same time increases revenues, wealth and future investment. But in our estimations the coefficient of $\ln w_{i,t}^F$ is always negative or not significantly different from zero, except for the group of likely financially constrained firms. Therefore this alternative explanation would require that likely financially constrained firms are on average more productive and grow faster than the other firms. But this hypothesis is rejected by the statistics in table I. More importantly the coefficient of $\ln \theta_{i,t}$, which represents an estimate of the productivity shock, has always the expected sign and size and is strongly significant, for the whole sample as well as for the likely unconstrained firms. The coefficient of $\ln \theta_{i,t}$ has a different value for the likely constrained firms, but the difference is almost never statistically significant. These considerations indicate that the differences in the coefficient of $\ln w_{i,t}^F$ across groups are unlikely to be driven by unobservable investment opportunities.

Another possible criticism is that the $\ln w_{i,t}^F$ coefficient captures changes in the user cost of capital that are not related to financing constraints. By introducing firm and year dummy variables we already take into account differences in the user costs of capital across firms or changes over time for all the firms. But one could object that the coefficient of $\ln w_{i,t}^F$ can be positive, even in the absence of financing imperfections, if an increase in wealth is systematically correlated to a positive shock in the quality of the firm's projects that makes also its investment less risky. We argue that it would be hard to justify such a systematic relationship. More importantly, if this is true then we should observe a positive coefficient of wealth for all firms, while this does not happen in our sample. The only possibility would then be that such systematic relationship only holds for likely financially constrained firms, because these are more risky, or because they are younger firms for which the quality of the management is very uncertain, and so their perceived riskiness is highly dependent on the current performance. The results shown before allow us to reject both arguments. First, even though younger firms have a higher coefficient of $\ln w_{i,t}^F$, this is not driving all the results. It is possible to show that if we exclude the younger firms from the sample (the $D^{age} = 1$ observations) we still obtain the same results illustrated in tables II and IV.[17] Second, likely financially constrained firms do not seem, on average, riskier than the other firms (see table I). Other robustness checks are illustrated in the following subsections $A-E$.

## A Capital and labour as dependent variables.

Our theory predicts that the coefficient of $\ln w_{i,t}^F$ in equation (37) identifies the intensity of financing constraints. A necessary condition for this result is that adjustment costs do not play a big role in determining $l_t$. This assumption is reasonable since $l_t$ measures variable inputs. It is not reasonable for $k_t$, which is the stock of fixed capital. Moreover in the context of Italian firms also labour input $n_t$ is a factor of production very costly to adjust, because of the big frictions in the Italian labour market.[18] Therefore, if our theory is correct, we expect that the coefficient of $\ln w_{i,t}^F$ would be unable to identify financing constraints if fixed capital or labour were used as dependent variable in equation (37). This is verified in table V, which replicates the analysis of table II with $k_t$ and $n_t$ as dependent variables. The first three columns estimate the labour demand equation. The coefficients estimated in the first column for the whole sample are not consistent with the structural parameters. For example, if we consider the elasticity of labour $\widehat{\gamma}$ to be equal to 0.3, the estimated elasticity of materials $\widehat{\beta}$, implied by the coefficient of $\ln l_{i,t}$, is equal to 0.315, which is less than half the materials share of revenues (see table III). This negative bias is presumably caused by the presence of labour adjustment costs, which imply that labour demand does not respond as flexibly as materials demand to the productivity shocks. This explains also why the estimated coefficient of $\ln \theta_{i,t}$ is not significant. In this context the finding that the coefficient of $\ln w_{i,t}^F$ is positive and significant for the whole sample cannot be interpreted as evidence of financing constraint, but rather as the result of the misspecification of the model. The fact that the coefficient of $\ln w_{i,t}^F$ is not higher for likely financially constrained than for likely financially unconstrained firms confirms this. The last three columns repeat the analysis using fixed capital ($\ln k_{i,t}$) as dependent variable and show a similar picture, with the estimated coefficients violating the restrictions of the structural model and the coefficient of $\ln w_{i,t}^F$ not being a useful indicator of financing constraints.

[17] Detailed results of the regressions performed after eliminating younger firms from the sample are available upon request.

[18] The Labour Law in Italy has stringent limits to the ability of firms to fire workers. More flexible types of employment have been introduced in the '90$s$, but our sample stops before that period.

## B Alternative definitions of wealth

The value of $w_{i,t}^F$, the variable that represents financial wealth, is negative for about 18% firm-year observations. In tables VI and VII we check whether this censoring of the sample affects the results. We estimate equation (37) using a normalization of $w_{i,t}^F$ that includes also a concave transformation of negative values. If all firms were of similar size, then we could simply have added a constant to the variable $w_{i,t}^F$ in order to make it positive for every firm-year observation. But in reality firms differ widely in their average size. Therefore we first normalize $w_{i,t}^F$ by multiplying it by $\overline{y}/\overline{y}_i$, where $\overline{y}_i$ is average real output of firm $i$ and $\overline{y}$ is average real output of the whole sample. Then we eliminate as outliers the smallest 1% of the values of $w_{i,t}^F \frac{\overline{y}}{\overline{y}_i}$, and we add a constant in order to make the financial wealth positive for all firm year observations. Finally, we divide again by $\overline{y}/\overline{y}_i$ :

$$w_{i,t}^{F\,norm} = \left( w_{i,t}^F \frac{\overline{y}}{\overline{y}_i} + constant \right) \frac{\overline{y}_i}{\overline{y}} \tag{39}$$

Moreover we also estimate equation (37) using a definition of wealth that does not include inventories, called $\widetilde{w}_{i,t}^F$. Table VI considers the estimations, for the 1988-91 sample, of the groups selected according to the direct criteria $\widehat{D}^{hs}$ and $\widehat{D}^{lc}$. The results confirm and strengthen the findings of tables II and IV. The first two columns use $\ln w_{i,t}^{norm}$ as a regressor. The estimated coefficients of $\ln \theta_{i,t}$, $\ln k_{i,t-1}$ and $\ln n_{i,t}$ for the likely unconstrained firms never reject the restriction imposed by the structural model, with the only exception of the coefficient of $\ln k_{i,t-1}$ for the $\widehat{D}^{lc} = 0$ group, which is positive but not significant at the 10% significance level. The same coefficients estimated for the likely financially constrained firms generally do not show significant deviations, while the coefficient of $\ln w_{i,t}^{norm}$ is very large and significant for these firms. The last two columns of table VI use $\ln \widetilde{w}_{i,t-1}^{norm}$, and show similar findings. Table VII proposes the same estimations using the indirect selection criteria $D^{age}, D^{divpol}$ and $D^{size}$. The results show that the coefficient of wealth is not significantly different from zero for the larger firms, for the firms that distribute dividends and for the older firms, while is positive and significant for the complementary groups. In both tables VI and VII the coefficient of $\ln w_{i,t}^F * D_{i,t}$ is larger and more precisely estimated with respect to the same coefficient estimated in tables II and IV, where negative wealth observations are censored. This finding is consistent with the view that the observations with lowest financial wealth belong to firms with an higher intensity of financing constraints. By including these observations we increase the variability of the intensity of financing constraints across the sample, and this allows us to estimate the parameter $\eta$ more precisely.

Among all the criteria used to split the sample, only the zero dividend policy has a limited ability to select firms with higher correlation of investment with internal finance. A plausible explanation of this finding is that for privately owned firms the zero dividend policy is not a very useful indicator of the intensity of financing constraints. This is because for many firms in the sample the controlling shareholders are also the managers of the firms. These firms may choose zero dividends not because they are financially constrained, but because they have other ways of distributing revenues (like in the forms of compensations to the managers) that are more tax efficient than dividends.

## C Using the 1989-1991 sample

In the previous sections the estimations that use the $\widehat{D}^{hs}$ and $\widehat{D}^{lc}$ dummies are relative to the sample with 4 years of data, from 1988 to 1991. Since in the Mediocredito survey all the questions explicitly refer to the 1989-91 period, in table (VIII) we repeat the analysis of tables II and V using only those three years of data. The results confirm the previous findings. The only difference is that the coefficient of fixed capital is often estimated to be not significantly different from zero. This is probably because fixed capital is less volatile than the other factors of production, and three years of data represent an amount of intra-firm variability too low to identify the fixed capital coefficient $\pi_2$.

## D Collateral value of the assets

The model developed in section III assumes that the firm cannot borrow collateralized debt, and therefore that any increase in leverage causes an increase in the interest rate charged by the lenders. In this section we show that allowing for the presence of collateral does not change the predictions of the model nor the interpretation of the results obtained in the empirical section of the paper.

If we assume that the firm has access to collateralized debt $b_t^c$, then the budget constraint (12) becomes:

$$d_t + l_t + k_t + \mu(i_t) = w_t^F + (1-\delta_k)k_{t-1} + \frac{b_t^c}{R} + \frac{b_t}{R_t} \tag{40}$$

Collateralized debt is cheaper but is limited by the value of the assets. We distinguish two cases:

1) the existing stock of capital is the collateral:

$$\begin{aligned} b_t^c &\leq \tau_k (1-\delta) k_{t-1} \\ 0 &< \tau_k \leq 1 \end{aligned} \tag{41}$$

The firm is financially constrained if equation (41) holds with equality. By substituting it into the budget constraint we get:

$$d_t + l_t + k_t + \mu(i_t) = w_t^F + (1-\delta_k)\left(1+\frac{\tau_k}{R}\right) k_{t-1} + \frac{b_t}{R_t} \tag{42}$$

Equation (42) implies that the bigger is $\tau_k$, the more $k_{t-1}$ matters for the financing of the firm. Therefore, the bigger is $\tau_k$, the bigger is likely to be coefficient $\kappa$ in equation (36). However this fact does not change the qualitative predictions of the model and the validity our test of financing constraints.

2) The variable capital is itself collateral. In this case we assume that:

$$\begin{aligned} b_t^c &\leq \tau_l l_t \\ 0 &< \tau_k \leq 1 \end{aligned} \tag{43}$$

By substituting equation 43 holding with equality in the budget constraint we get:

$$d_t + \left(1-\frac{\tau_l}{R}\right) l_t + k_t + \mu(i_t) = w_t^F + (1-\delta_k)k_{t-1} + \frac{b_t}{R_t} \tag{44}$$

The larger is $\tau_l$, the smaller is the financial wealth needed to finance variable investment. This is equivalent to assume that $w^{\max}$ is smaller. Therefore if $\tau_l$ is very large then no firm needs to raise costly debt to finance variable capital, and financial wealth should be not significant in equation (37) for both likely constrained and likely unconstrained firms. We find the opposite, and this confirms that $\tau_l$ is relatively small in our sample. This finding is realistic, because even though variable inputs are partly financed with trade credit, which is usually considered a form of collateralized debt, in practice trade credit is very costly. The annualized interest rate that firms implicitly pay on trade credit is often found to be above 40% (Ng *et al.*, 1999).

## E Comparison with the Euler equation approach

In the previous sections we have shown that the estimation of equation (37) is able to identify the intensity of financing constraints on firm investment. But we still need to prove that this method is more efficient than the methods employed in the previous literature. As virtually all of the firms in our sample are not quoted on the stock market, it is not feasible to estimate the $q$ model for them. Thus we consider the "Euler equation approach", and we estimate the equation proposed by Bond and Meghir (1994):

$$\left(\frac{i}{k}\right)_{i,t}=\beta_1\left(\frac{i}{k}\right)_{i,t-1}+\beta_2\left(\frac{i}{k}\right)^2_{i,t-1}+\beta_3\left(\frac{cf}{k}\right)_{i,t-1}+\beta_4\left(\frac{y}{k}\right)_{i,t-1}+\beta_5\left(\frac{b}{k}\right)^2_{i,t-1}+d_t+a_i+\nu_{i,t} \tag{45}$$

Equation (45) is related to equation (24) in section III. The difference is that Bond and Meghir (1994) derive equation (45) by assuming that there are no financing imperfections, and that adjustment costs are quadratic in the gross investment ratio $\left(\frac{i}{k}\right)$. They also impose a set of additional assumptions that allow to substitute $MPK_t$ with a linear function of $\left(\frac{i}{k}\right)_{i,t-1}$ ,$\left(\frac{i}{k}\right)^2_{i,t-1}$ and $\left(\frac{cf}{k}\right)_{i,t-1}$.[19] According to this framework the coefficient of $\left(\frac{y}{k}\right)_{i,t-1}$ should be positive in case of imperfect competition among firms and zero in the case of perfect competition. The coefficient of $\left(\frac{b}{k}\right)^2_{i,t-1}$ should be negative in the presence of debt tax shield and zero otherwise. The coefficient of $\left(\frac{i}{k}\right)_{i,t-1}$ should be positive and greater than one, and the coefficient of $\left(\frac{i}{k}\right)^2_{i,t-1}$ should be negative and greater than one in absolute value. Finally the coefficient of $\left(\frac{cf}{k}\right)_{i,t-1}$ should be negative in the absence of financing constraints. The idea of this test is that any misspecification of the model induced by the presence of financing constraints should be captured by a positive coefficient of $\left(\frac{cf}{k}\right)_{i,t-1}$. The first column of table IX shows the estimation of equation (45) for the whole sample for the 1988-91 period. The coefficients of $\left(\frac{i}{k}\right)_{i,t-1}$ and $\left(\frac{i}{k}\right)^2_{i,t-1}$ have the expected signs but are much smaller than the magnitude implied by the presence of quadratic adjustment costs. This bias is well known, and is likely to be caused by the misspecification of the model due to the presence of non convex adjustment costs. The coefficient of lagged cash flow is instead significantly positive for the whole sample, as frequently reported in other studies. This finding should be interpreted as a result of the misspecification of the model rather than as evidence of financing imperfections. In other words the cash flow coefficient is positive because some factors that are not correctly represented in equation (45), for example

[19] See page 207 of Bond and Meghir (1994) for details.

positive shocks to future investment opportunities, cause an increase in both investment and cash flow. In the other columns of table IX we allow the estimated coefficients to vary across subgroups of likely financially constrained firms. The cash flow coefficient is significantly higher for likely financially constrained firms only for the $\widehat{D}^{hs} = 1$ and $D^{age} = 1$ groups, and only at the 10% significance level. Taken together the results in table IX do not allow a clear conclusion on wether or not the investment of the firms in the sample is financially constrained. They are much less informative than the results in tables II-IV and VI-VII, where the coefficient of $\ln w_{i,t}^F$ is found to be a more precise indicator of the intensity of financing constraints. We also estimate equation (45) using only observations with positive wealth, so that the sample is comparable to the one used in tables II-IV. At the bottom of table IX we only report, for brevity, the estimated coefficients of $\left(\frac{cf}{k}\right)_{i,t-1}$ and $\left(\frac{cf}{k}\right)_{i,t-1} * D_{i,t}$, which again do not show significant differences in the cash flow coefficient between likely constrained and likely unconstrained firms. In table X we estimate equation (45) by replacing cash flow $\left(\frac{cf}{k}\right)_{i,t-1}$ with financial wealth $\left(\frac{w^F}{k}\right)_{i,t-1}$. The results do not change significantly with respect to the previous table IX.

# VII Conclusions

In this paper we analyzed the effect of financing constraints on the investment decisions of small privately owned firms. We estimated a financing constraints test derived from a structural model with adjustment costs of fixed capital and with an upward sloping cost of external finance.

The model predicts that the investment in variable inputs is positively correlated to internal finance for a financially constrained firm, and that we can use a variable investment reduced form equation to detect both the presence and the intensity of financing constraints on firm investment. Because the investment in variable capital is affected by the current productivity shock rather than by the forward looking marginal $q$, our test can be performed using only information commonly available on balance sheet data, and it can be easily applied to small firms not quoted on the stock markets.

The estimation results, based on a sample of Italian manufacturing firms, do not reject the restrictions imposed by the structural parameters. The consequence of the correct specification of the model is that the sensitivity of variable investment to internal finance is a precise indicator of the intensity of financing constraints. This sensitivity is never significantly positive, and is always very small, for the groups of firms a priori not expected to be financially constrained. By contrast, it is always significantly greater than zero, and often large, for likely financially constrained firms. With respect to the previous literature, this paper shows that we can successfully estimate the intensity of financing constraints in an economy by focusing on small firms and using a test based on a variable investment equation. This finding is useful for the literature about financing imperfections and aggregate fluctuations, such as the literature on the financial accelerator and that on the credit channel of monetary policy.

# References


[1] Abel, A.B. and O. Blanchard (1986), "The Present Value of Profits and Cyclical Movements in Investment" *Econometrica*, 54(2), 249-73.

[2] Abel, A. and J.C. Eberly, 1994, A Unified Model of Investment Under Uncertainty, *American Economic Review,* 84, 1369-84.

[3] Abel, A. and J.C. Eberly, 2002, Investment and q with Fixed Costs: An Empirical Analysis, Mimeo, Northwestern University.

[4] Abel, A. and J.C. Eberly, 2003, Q Theory Without Adjustment Costs & Cash Flow Effects Without Financing Constraints, Mimeo, University of Pennsylvania.

[5] Abel, A. and J.C. Eberly, 2004, Investment, Valuation and Growth Options, Mimeo, Northwestern University.

[6] Albuquerque, R. and H.A. Hopenhayn, 2004, Optimal Dynamic Lending Contracts and Firm Dynamics, *The Review of Economic Studies,* 71, 285-315.

[7] Almeida, E. and M. Campello, 2005, Financial Constraints, Asset Tangibility and Corporate Investment, mimeo, New York University.

[8] Almeida, E., Campello, M. and M.S. Weisbach, 2004, The Cash Flow Sensitivity of Cash, *Journal of Finance,* 59, 1777-1804.

[9] Alti, A., 2003, How Sensitive Is Investment to Cash Flow When Financing Is Frictionless, *Journal of Finance*, 58, 707-22.

[10] Arellano, M. and S. Bond, 1991, Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations, *Review of Economic Studies*, 58, 277-97.

[11] Barnett, S. and P. Sakellaris, Non-linear Response of Firm Investment to Q: Testing a Model of Convex and Non-Convex Adjustment Costs, *Journal of Monetary Economics*, 42, 261-288.

[12] Basile, R., Giunta, A. and J.B. Nugent, 2003, Foreign Expansion by Italian Manufacturing Firms in the Nineties: An Ordered Probit Analysis; *Review of Industrial Organization*, 2003, 23, 1-24

[13] Bartelsman, E., Scarpetta, S. and F. Schivardi, 2003, Comparative Analysis Of Firm Demographics And Survival: Micro-Level Evidence For The Oecd Countries, OECD Economics Department Working Paper No. 348.

[14] Bernanke, B., Gertler, M. and S. Gilchrist, (1998), "The Financial Accelerator in a Quantitative Business Cycle Framework, *Handbook of Macroeconomics.*

[15] Besanko, D. and A.V. Thakor, 1986, Collateral and Rationing: Sorting Equilibria in Monopolistic and Competitive Credit Markets, *International Economic Review* 28, 671-89.

[16] Blundell, R. and S. Bond, 1998, Initial Conditions and Moment Restrictions in Dynamic Panel Data Models, *Journal of Econometrics* 87, 115-43.

[17] Bond, S., Elston, J., Mairesse, J. and B. Mulkay, 2003, Financial Factors And Investment In Belgium, France, Germany, And The United Kingdom: A Comparison Using Company Panel Data, By, *The Review of Economics and Statistics*, 85.

[18] Bond, S. and C. Meghir, 1994, Dynamic Investment Models and the Firm's Financial Policy, *Review of Economic Studies 61, 197-222.*

[19] Bond, S., Klemm, A., Newton-Smith, R., Syed, M., and Vlieghe Gertjan, 2004, "The Roles of Expected Profitability, Tobin's Q and Cash Flow in Econometric Models of Company Investment", IFS working paper 04/12

[20] Caballero, R.J., Engel, E. and J. Haltiwanger, 1995, Plant-Level Adjustment and Aggregate Investment Dynamics, *Brookings Papers on Economic Activity,* 1-54.

[21] Cabral, L. and J. Mata, 2003. "On the Evolution of the Firm Size Distribution: Facts and Theory," *American Economic Review*, 93, 1075-1090.

[22] Caggese A., 2005, Testing Financing Constraints on Firm Investment Using Variable Capital, Pompeu Fabra University working paper

[23] Carpenter,R.E., Fazzari S.M. and B. Petersen (1998), "Financing Constraints and Inventory Investment: A Comparative Study with High-Frequency Panel Data", *The Review of Economics and Statistics*, 80, 513-519.

[24] Carpenter,R.E. and B. Petersen (2003), Is the Growth of Small Firms Constrained by Internal Finance?, *Review of Economics and Statistics* 84(2), 298-309.

[25] Cleary, S., 1999, The Relationship between Firm Investment and Financial Status, *Journal of Finance* 54, 673-692.

[26] Doms, M. and T. Dunne, 1998, Capital Adjustment Patterns in Manufacturing Plants, *Review of Economic Dynamics,* 1, 409-429.

[27] Eberly, J., 1997, *International Evidence on Investment and Fundamentals*, European Economic Review, 41, 1055-1078.

[28] Erickson, T. and T. Whited, 2000, Measurement Error and the Relationship between Investment and q, *Journal of Political Economy* 108, 1027-57

[29] Fazzari S.M., Hubbard G.R. and B.C. Petersen, 1988, Financing Constraints and Corporate Investment, *Brooking Papers on Economic Activity* 1, 141-195.

[30] Gelos, R. and A. Werner, 2002, Financial Liberalization, Credit Constraints, and Collateral: Investment in the Mexican Manufacturing Sector, *Journal of Development Economics*, 67, 1-27.

[31] Gertler, M. and S. Gilchrist (1994), "Monetary Policy, Business Cycle, and the Behaviour of Small Manufacturing Firms", *Quarterly Journal of Economics*, 109, 309-340.

[32] Gilchrist, S and Himmelberg, C., 1995, "Evidence on the role of cash flow for investment," *Journal of Monetary Economics*, 36, 541-572.

[33] Gilchrist, S and Himmelberg, C., 1998, Investment, Fundamentals, and Finance, in Bernanke, B. and Rotemberg, J. (eds), *NBER Macro Annuals 1998,* Cambridge, MIT press, 223-274.

[34] Gomes, J., 2001, Financing Investment, *American Economic Review* 91, 1263-1285.

[35] Guiso, L. and G. Parigi, 1999, Investment and Demand Uncertainty, *Quarterly Journal of Economics*, 114, 185-227.

[36] Hall, B.H. and J. Mairesse, 1996, Estimating the Productivity of Research and Development: An Exploration of GMM Methods Using Data on French & United States Manufacturing Firms, NBER WP #5501.

[37] Hart,O and J.H. Moore, 1998, Default and Renegotiation: a Dynamic Model of Debt, *Quarterly Journal of Economics* 113, 1-41.

[38] Hayashi, F., 1982, Tobin's Marginal and Average $q$: a Neoclassical Interpretation, *Econometrica, 50, 213-24.*

[39] Hennessy, C., Levy, A. and T. Whited, 2005,"Testing Q Theory with Financing Frictions", mimeo, University of Winsconsin.

[40] Hubbard, G.R., 1998, Capital-Market Imperfections and Investment, *Journal of Economic Literature* 36, 193-225.

[41] Kaplan, S. and L. Zingales, 1997, Do Investment-Cash Flow Sensitivities Provide Useful Measures of Financing Constraints?, *Quarterly Journal of Economics* 112, 169-215.

[42] Kashyap, A., Lamont, O. and J. Stein, 1994,"Credit Conditions and the Cyclical Behavior of Inventories" *The Quarterly Journal of Economics*, 109, 565-92.

[43] Jaramillo, F., Schiantarelli, F. and A. Weiss, 1996, Capital Market Imperfections before and after Financial Liberalization: An Euler Equation Approach to Panel Data for Ecuadorian Firms, *Journal of Development Economics*, 51, 367-86

[44] Lízal, L. and J. Svejnar, 2002, Credit Rationing, And The Soft Budget Constraint: Evidence From Czech Panel Data, *Review of Economics and Statistics*, Vol. 84, Issue 2

[45] Milde, H. and J.G. Riley, 1988, Signalling in Credit Markets, *Quarterly Journal of Economics* 103, 101-129.

[46] Moskowitz, T. and A. Vissing-Jørgensen, 2002, The Returns to Entrepreneurial Investment: A Private Equity Premium Puzzle?, *American Economic Review*, 92, 745-78.

[47] Ng, C.K., Smith J.K. and R.L.Smith, (1999) "Evidence on the Determinants of Credit Terms Used in Interfirm Trade" *Journal of Finance, 54, 1109-29.*

[48] Pratap, S., 2003, Do Adjustment Costs Explain Investment-Cash Flow Insensitivity?, *Journal of Economic Dynamics and Control*, 27, 1993-2006.

[49] Piga, G., 2002, Debt and Firms' Relationships: The Italian Evidence, *Review of Industrial Organization*, 20, 267-82.

[50] Shea, J., 1997, Instrument Relevance in Multivariate Linear Models: A Simple Measure, *Review of Economics and Statistics*, 49, 348-352.

[51] Whited, T., 2004, External Finance Constraints and the Intertemporal Pattern of Intermittent Investment, Mimeo, University of Wisconsin.

[52] Windmeijer, F., 2005, A finite sample correction for the variance of linear efficient two-step GMM estimators, *Journal of Econometrics,* 126, 25-51.

# Appendix 1

Since $\Phi_t(b^{\max}) = 0$, it follows that the firm never wants to borrow the amount $b^{\max}$, because at the margin it does not receive anything today from increasing the face value of its debt by one unit. In order to prove that the firm also never wants to borrow more than $b^{\max}$ it is sufficient to prove that $\frac{\partial \Phi_t}{\partial b_t} < 0$. By differentiating equation (6) and rearranging we get:

$$\frac{\partial \Phi_t}{\partial b_t} = -\frac{2}{\overline{\overline{b}}} \frac{f'(b_t)}{f(b_t)} \Phi_t - \frac{1}{R\overline{\overline{b}}} \frac{f''(b_t)}{f(b_t)^2} < 0$$

$\frac{\partial \Phi_t}{\partial b_t}$ is always negative because of assumption 1 and because profit maximization implies that $\Phi_t$ cannot be negative.

## Appendix 2

Equation (20) describes the first order condition of fixed capital under the assumption of a continuous and differentiable adjustment cost function $\mu_t$. But also in case of fixed costs or irreversibility of fixed capital it is possible to derive and analogous expression.

- **Irreversibility:** in this case we substitute condition (3) with the following irreversibility constraint:

$$k_t \geq (1-\delta)\, k_{t-1} \tag{46}$$

The firm maximizes (15) subject to (13), (46) and the following budget constraint:

$$d_t + l_t + i_t = w_t^F + \frac{b_t}{R_t} \tag{47}$$

Let $\phi_t$ and $\mu_t^{IRR}$ be the Lagrangian multipliers associated with constraints (13) and (46). In this case the first order conditions for $l_t$ and $b_t$ are unchanged, while the first order condition for $k_t$ can be shown to be the following:

$$\alpha \theta_t k_t^{\alpha-1} l_t^{\beta} = UC_t - (1-\delta) + UC_t \left[ \frac{R\mu_t^{IRR} - (1-\delta_k)\, E_t\left(\mu_{t+1}^{IRR}\right)}{R\,(1+\phi_t)} \right] \tag{48}$$

Equation (48) is analogous to (20). The only difference is that marginal adjustment costs are represented by the shadow value of the irreversibility constraint, which is the value of the Lagrange multiplier $\mu_t^{IRR}$.

- **Fixed adjustment costs:** in this case condition (3) becomes the following:

$$\mu\,(i_t) = \ 1\,(i_t \neq 0)\, F$$

Where $F$ is a positive constant and $1\,(i_t \neq 0)$ is an indicator function that has value equal to 1 if the argument is true and zero otherwise. We can denote with $V_t^{NI}\,(w_t, \theta_t, k_{t-1})$ the value function conditional on not investing and not paying the fixed cost $F$ in period $t$, and $V_t^{I}\,(w_t, \theta_t, k_{t-1})$ the value function conditional on investing and paying the fixed cost $F$ in period $t$. The first order condition of fixed capital determines $k_t$ when $V_t^{I}\,(w_t, \theta_t, k_{t-1}) > V_t^{NI}\,(w_t, \theta_t, k_{t-1})$. In this case equation (20) can be written as:

$$\alpha \theta_t k_t^{\alpha-1} l_t^{\beta} = UC_t - (1-\delta) + UC_t \left[ \frac{(1-\delta)}{R\,(1+\phi_t)} F \frac{\partial E_t\left[(1+\phi_{t+1})\, 1\,(i_{t+1} \neq 0)\right]}{\partial i_{t+1}} \right] \tag{49}$$

Therefore also in this case adjustment costs affect the relationship between user cost and marginal productivity of capital. If $V_t^{I}\,(w_t, \theta_t, k_{t-1}) \leq V_t^{NI}\,(w_t, \theta_t, k_{t-1})$ then $k_t = (1-\delta)\, k_{t-1}$ and the marginal productivity fixed capital is insensitive to changes in $UC_t$ induced by changes in internal finance. If $V_t^I(w_t, \theta_t, k_{t-1}) > V_t^{NI}(w_t, \theta_t, k_{t-1})$ then fixed capital $k_{t+1}$ is determined by the first order condition (49), but also in this case future expected adjustment costs affect the relationship between marginal productivity and user cost of fixed capital.

# Appendix 3

Proof of proposition 1.

Because of the premium in the cost of external finance, the firm always prefers to use internal finance to fund investment. If $w_t^F$ is equal to $w_t^{MAX}$ then $b_t = 0$ and $UC_t = R$. In this case variable capital $l_t^*$ and fixed capital $k_t^*$ are the unconstrained investment levels that satisfy the following two conditions:

$$\alpha\theta_t k_t^{\alpha-1} l_t^{\beta} = R\left\{1-(1-\delta)+\left\{\mu_t' - \frac{(1-\delta)E_t\left[(1+\phi_{t+1})\mu_{t+1}'\right]}{R(1+\phi_t)}\right\}\right\} \tag{50}$$

$$\beta\theta_t k_t^{\alpha} l_t^{\beta-1} = R \tag{51}$$

By substituting $l_t^*$ and $k_t^*$ in the budget constraint evaluated at $d_t = 0$, we obtain the definition of $w_t^{\max}$ :

$$w_t^{\max} = l_t^* + k_t^* + \mu\left(k_t^* - (1-\delta)k_{t-1}\right) \tag{52}$$

Suppose now that $w_t^F < w_t^{\max}$. $l_t^*$ and $k_t^*$ are no longer optimal because they can only be financed raising costly debt that increases $UC_t$. The firm could instead choose $\widehat{l}_t$ and $\widehat{k}_t$ so that equation (52) is still satisfied with equality:

$$w_t = \widehat{l}_t + \widehat{k}_t + \mu\left(\widehat{k}_t - (1-\delta\Big)k_{t-1}\right) \tag{53}$$

But also this cannot be a solution, because if the firm does not borrow then $b_t = 0$, $UC_t = R$ and $\widehat{l}_t$ and $\widehat{k}_t$ are lower than the optimal level. Therefore the optimal solution implies $b_t > 0$ and $UC_t > R$. The same reasoning can be applied to show that if $w_t^F$ further decreases, the firm gradually reduces investment. The marginal productivity of investment increases and the firm will be willing to borrow more even though borrowing becomes more costly. Because marginal productivity of capital is decreasing, the firm accepts larger and larger increases in the interest rate. Therefore $\frac{\partial UC_t}{\partial w_t^F} < 0$ and $\frac{\partial^2 UC_t}{\partial\left(w_t^F\right)^2} > 0$. This proves proposition 1.

Equation (52) shows that $k_{t-1}$ and $w_t^{\max}$ are negatively related. This is obvious if $\mu\left(k_t^* - (1-\delta)k_{t-1}\right)$ is constant or decreasing in $k_{t-1}$. But it also applies if $\mu\left(k_t^* - (1-\delta)k_{t-1}\right)$ increases in $k_{t-1}$. Consider for example the situation in which the function $\mu(.)$ is positive and increasing in the absolute value of $i_t$ (as it happens in the case of quadratic adjustment costs), and that $k_t^* < (1-\delta)k_{t-1}$. In this case an increase in $k_{t-1}$ also increases expected adjustment costs and increases $k_t^*$ and $l_t^*$. But in equilibrium marginal adjustment costs are only a fraction of the user cost of fixed capital. Therefore this effect reduces the sensitivity of $w_t^{\max}$ to $k_{t-1}$, but it does not change its sign. This proves corollary 2.

# Appendix 4

Under the assumption that the firm also uses labour $n_t$, and that newly installed fixed capital $k_t$ takes one period to become productive, the budget constraint of the problem becomes the following:

$$d_t + k_t + l_t + n_t + \mu_t = w_t + \frac{b_t}{R_t} \tag{54}$$

And the definition of wealth becomes:

$$w_t = \theta_{t-1} k_{t-2}^{\alpha} l_{t-1}^{\beta} n_{t-1}^{\gamma} - b_{t-1} + (1 - \delta_k) k_{t-1} \tag{55}$$

Note that equations (54) and (55) imply that a unit of capital installed during time $t$ increases the stock of productive fixed capital by one unit in period $t+1$, and has a residual market value of $(1-\delta)$ during the same period. Therefore the problem becomes:

$$V_t(w_t, \theta_t, k_{t-1}) = \underset{\{k_{t+1}, b_t, l_t\}_{t=1}^{\infty}}{MAX} (1+\phi_t)\left(w_t + \frac{b_t}{R_t} - k_t - l_t - \mu_t\right) + \frac{1}{R} E_t\left[V_{t+1}(w_{t+1}, \theta_{t+1}, k_t)\right] \tag{56}$$

Under the new assumptions the first order condition for $b_t$ does not change, while the one for $l_t$ becomes:

$$-(1+\phi_t) + \frac{1}{R}\left[\frac{\partial E_t\left[V_{t+1}(w_t, \theta_{t+1}, k_{t+1})\right]}{\partial w_t} \beta \theta_t k_{t-1}^{\alpha} l_t^{\beta-1} n_t^{\gamma}\right] = 0 \tag{57}$$

By using equation (17) in (57) we get:

$$\beta \theta_t k_{t-1}^{\alpha} l_t^{\beta-1} n_t^{\gamma} = UC_t \tag{58}$$

Equation (58) implies that proposition 1 still holds, conditional also on $n_t$. Moreover we can rearrange (58) to derive equation (34).

# Appendix 5

We describe here the variables used in the empirical analysis of the paper:

$p_t^y y_{i,t}$: total revenues realized during year $t$, at current prices.

$p_t^k k_{i,t}$: sum of the replacement value of: i) plants and equipment; ii) intangible fixed capital (Software, Advertising, Research and Development). We include in $p_t^k k_{i,t}$ all capital purchased before the end of time $t$. Balance sheet data about fixed assets do not reflect their replacement value, for at least two reasons: first, the depreciation rate applied for accounting purposes does not always coincide with the physical depreciation rate; second, all the values are "historical", and do not usually take into account the appreciation of the assets in nominal terms. Therefore we compute the replacement value of capital by adopting the following perpetual inventory method:

$$p_{t+1}^{k^j} k_{i,t+1}^j = p_t^{k^j} k_{i,t}^j (1+\pi_t^j)(1-\delta^j) + p_{t+1}^{k^j} i_{i,t+1}^j$$

$j$={1,2} , where 1=plant and equipment and 2= intangible fixed capital . $\pi^1$ = % change in the producer prices index for agricultural and industrial machinery (source: OECD, from Datastream); $\pi^2$ = % change in the producer prices index (source: OECD, from Datastream). $\delta^j$ are estimated separately for the 20 manufacturing sectors using aggregate annual data about the replacement value and the total depreciation of the capital (source: Italian National Institute of Statistic). Given that within each sector depreciation rates vary only marginally between years, we conveniently used the average over the sample period: $\delta^1$ ranges from 9.3% to 10.7%, and $\delta^2$ from 8.4% to 10.6%.

$p_t^l l_{i,t}$ : this variable measures the usage of variable inputs, at current prices, and is computed in the following way: beginning of the period $t$ input inventories (materials and work in progress), plus new purchases of materials in period $t$, minus end of period $t$ input inventories.

$p_t^n n_{i,t}$ : this variable includes the total cost of the labour in year $t$, at current prices.

$p_t^w w_{i,t}^F$ = liquidity at the end of period $t-1$ plus net short term credit plus the stock of finished goods inventories at the end of period $t-1$. Net short term credit is the difference between credit and debt that expires before the end of time $t$ (both banking and commercial debt and credit are included)

$p_t^w \widetilde{w}_{i,t}^F$ = liquidity at the end of period $t-1$ plus net short term credit.

In order to transform the variables in real terms, we used the following price indexes (source: ISTAT, the Italian National Statistics Institute):

$p_t^y$: consumer prices index relative to all products excluding services.

$p_t^w$ : same as $p_t^y$.

$p_t^k$ : producer price index of durable inputs.

$p_t^n$ : wage earnings index of the manufacturing sector.

$p_t^l$: wholesale price index for intermediate goods.

# Appendix 6

In this section we illustrate the procedure used to estimate the productivity shock $\ln \theta_{i,t}$. First, we directly estimate the output elasticities to factor inputs $\alpha, \beta$ and $\gamma$. We consider the production function in equation (33). Table XI reports summary statistics of $y_{i,t}$,$k_{i,t}$,$l_{i,t}$and $n_{i,t}$. By taking logs, we have the following linearized version of equation (33):

$$\ln y_{i,t} = a_i + d_t + x_{s,t} + \alpha \ln k_{i,t-1} + \beta \ln l_{i,t} + \gamma \ln n_{i,t} + \varepsilon_{i,t} \tag{59}$$

$a_i$ is the firm fixed effect. $d_t$ is the time effect and $x_{s,t}$ is the sector effect (we consider two digit sectors as classified by ISTAT, the Italian National Statistical Institute). In order to allow some heterogeneity in the technology employed by firms in different sectors, equation (59) is separately estimated for seven groups of firms. Each group is composed of firms with as homogeneous as possible production activity. Table XII shows the composition of the groups. Because we estimate equation (33) also for those firms that split or merged during the sample period, the total number is 561 firms. Equation (59) is estimated by first differencing and then using GMM with instrumental variables, on the sample from 1985 to 1991.[20] This means that we exclude year 1982, in order to diminish possible distortions caused by the perpetual inventory method, and we have the data from 1983 and 1984 available as instruments. Table XIII reports

[20]Such method is used for a similar problem by Hall and Mairesse (1996). We use both lagged first differences and levels as instruments for the equation in first differences. We consider lags - 1and -2. The estimated coefficients are very similar to those obtained using the SYSTEM GMM estimation method.

estimation results. The first column is relative to the whole sample, while the next seven columns show the estimates of $\widehat{\alpha}$, $\widehat{\beta}$ and $\widehat{\gamma}$ for the seven groups separately. The Wald test shows that the restriction $\widehat{\alpha}+\widehat{\beta}+\widehat{\gamma}=1$ is rejected in favor of $\widehat{\alpha}+\widehat{\beta}+\widehat{\gamma}<1$ for all groups except group 7. The estimated output elasticity of variable capital $\widehat{\beta}$ ranges between 0.29 and 0.56, and in three groups it is higher than the output elasticity of labour $\widehat{\gamma}$. These high estimates of $\beta$ are quite common in firm-level estimates of the production function (see for example Hall and Mairesse, 1996). Output elasticity of fixed capital $\widehat{\alpha}$ ranges between 0.04 and 0.11. This range of values is reasonable and consistent with the factor shares of output, given the amount of fixed capital as opposed to variable capital used in the production (see tables III and XI), and the difference in the user costs of fixed and variable capital caused by the difference in the depreciation factors.[21] The overidentifying restrictions are rejected for the estimation of the whole sample, but not for single group estimations. Using the estimated elasticities $\widehat{\alpha}$, $\widehat{\beta}$ and $\widehat{\gamma}$ we compute total factor productivity for all the firm years observations:

$$\widehat{TFT}_{i,t}=\ln y_t-\widehat{\alpha}\ln k_{i,t-1}+\widehat{\beta}\ln l_{i,t}-\widehat{\gamma}\ln n_{i,t} \tag{60}$$

We then regress $\widehat{TFT}_{i,t}$ on fixed effects, year and sector dummy variables. The estimated residual from this regression is $\ln\widehat{\theta}_{i,t+1}$, which is the estimated productivity shock at the beginning of period $t+1$.

## Appendix 7

Table XIV shows the tests of the validity of the instruments for the estimation of equation (37). The upper part reports the p-value of the *Hansen J* statistic that tests the orthogonality of the instruments. This test is robust to heteroskedasticity and autocorrelation of unknown form. The validity of the t-1 to t-3 first differences as instruments of the equation in levels is not rejected for all the cross sectional equations. The validity of the t-2 to t-3 levels as instruments of the equation in first differences is rejected for the 1987 and 1991 cross sectional equations. This causes these instruments to be also rejected when we estimate all cross sectional equations simultaneously using the System GMM estimator. Therefore we decide to eliminate the t-2 levels from the sets of instruments when we estimate equation (37). The bottom part of table XIV reports, from the first stage regressions, the statistics regarding the validity of the instruments. The F statistic of the excluded instruments and the partial $R^2$ from Shea (1997) are reported. Both sets of information show that the combination of first differences and levels instruments, employed by the System GMM estimator, are sufficiently correlated to the regressors for the coefficients of equation (37) to be identified.

[21] The yearly depreciation rate of plant and equipment is around 10%, while the depreciation rate of the usage of materials is by construction equal to 100%.

Table I: Summary statistics, years 1982-1991

| | All firms | $D^{hs}=1$ | $\widehat{D}^{hs}=1$ | $D^{lc}=1$ | $\widehat{D}^{lc}=1$ |
|---|---|---|---|---|---|
| Mean fixed assets[3] | 6331 | 3136 | 4556 | 4140 | 3419 |
| Median fixed assets | 2442 | 2200 | 2773 | 3064 | 2551 |
| Mean n. of employees | 207 | 141 | 144 | 175 | 129 |
| Median n. of empl. | 123 | 119 | 112 | 131 | 114 |
| 90th percentile of empl. | 433 | 249 | 269 | 364 | 243 |
| Short t. banking debt/K | 0.50 (0.15) | 0.54 (0.13) | 0.52 (0.14) | 0.51 (0.14) | 0.52 (0.15) |
| Long t. banking debt/K | 0.10 (0.08) | 0.11 (0.09) | 0.16 (0.10) | 0.11 (0.07) | 0.11 (0.09) |
| Avg. cost of debt[2] | .066 (.035) | .075 (.037) | .072 (.028) | .076 (.036) | .073 (.031) |
| Gross income margin | .066 (.058) | .065 (.046) | .063 (.068) | .068 (.063) | .063 (.052) |
| Net income margin | .018 (.05) | .01 (.034) | .002 (.06) | .014 (.05) | .009 (.045) |
| Net sales growth | 0.11 (0.19) | 0.11 (0.17) | 0.13 (0.21) | 0.12 (0.20) | 0.12 (0.21) |
| Financial wealth/K[1] | 1.17 (1.7) | 0.80 (1.21) | 0.58 (1.31) | 0.88 (1.08) | 0.91 (1.49) |
| Cash Flow/K | 0.41 (0.57) | 0.29 (0.26) | 0.26 (0.33) | 0.35 (0.43) | 0.32 (0.35) |
| Investment/K | 0.30 (0.34) | 0.28 (0.30) | 0.31 (0.33) | 0.30 (0.28) | 0.30 (0.40) |
| Volatility of output[4] | 1.18 (0.22) | 1.17 (0.24) | 1.18 (0.24) | 1.21 (0.25) | 1.19 (0.21) |
| Number of firms | 415 | 63 | 56 | 56 | 70 |
| N. of observations | 4150 | 630 | 560 | 560 | 700 |

Standard deviations in parenthesis. K=fixed assets. Financial wealth= liquidity at the end of period $t-1$ plus net short term credit (net credit that expires before the end of time $t$) plus the stock of finished goods inventories at the beginning of period $t$. 1) Largest 1% and smallest 1% excluded from the computation of this statistic. 2) Interest paid on banking debt divided by total banking debt. Average on the 1989-91 period. 3) Values are in billions of Italian Liras, 1982 prices. 1 Billion liras was equal to 0.71 million US$ at the 1982 exchange rate. 4) Average of the standard deviation of the growth rate of sales.

Table II: Financing constraints test: direct revelation criteria

| Regression: $\ln l_{i,t} = \pi_0 + a_i + d_t + \pi_1 \ln \theta_{i,t} + \pi_2 \ln k_{i,t-1} + \pi_3 \ln n_{i,t} + \pi_4 \ln w^F_{i,t} + \varepsilon_{i,t}$ | | | | |
|---|---|---|---|---|
| | 1986-91 sample | 1988-1991 sample | | |
| | All firms | All firms | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ |
| $\ln k_{i,t-1}$ | **0.26 (2.8)** | **0.19 (1.9)** | **0.20 (2.3)** | **0.21 (2.7)** |
| $\ln n_{i,t}$ | **0.77 (6.4)** | **0.71 (5.7)** | **0.75 (5.4)** | **0.71 (5.7)** |
| $\ln \theta_{i,t}$ | **1.99 (2.0)** | **2.78 (2.4)** | **3.06 (2.4)** | **3.07 (2.6)** |
| $\ln w^F_{i,t}$ | -0.05 (-1.6) | **-0.08 (-2.4)** | -0.07 (-1.9) | **-0.09 (-2.5)** |
| $\ln k_{i,t-1}{*}D_{i,t}$ | | | -0.01 (-0.1) | -0.13 (-0.6) |
| $\ln n_{i,t}{*}D_{i,t}$ | | | -0.19 (-0.8) | **-0.65 (-2.1)** |
| $\ln \theta_{i,t}{*}D_{i,t}$ | | | -5.01 (-1.5) | 4.3 (0.9) |
| $\ln w^F_{i,t}{*}D_{i,t}$ | | | **0.43 (3.2)** | **0.31 (3.5)** |
| n. Obs. | 1666 | 1127 | 1127 | 1127 |
| $F$ test | 50 (0.0) | 34 (0.0) | 19.4 (0.0) | 15 (0.0) |
| *Hansen* test | 104 (85) | 50 (57) | 96 (117) | 105 (117) |
| p-value | 0.073 | 0.716 | 0.928 | 0.778 |

The coefficients are estimated with a two step robust System GMM estimator (Blundell and Bond, 1998). The t-statistic is reported in parenthesis. Coefficients significant at the 95% confidence interval are in bold. The finite-sample correction to the two-step covariance matrix is derived by Windmeijer (2005). We use the command Xtabond2 on the software package Stata. The variables are described in appendix 5. The smallest 1% and largest 1% of the first differences of the regressors and of the dependent variable are eliminated as outliers. Year dummy variables are entered as strictly exogenous regressors.

Instruments for the equation in levels are t-1 to t-3 first differences of the regressors and t-2 to t-3 the first differences of the dependent variable. Instruments for the equation in first differences are t-3 levels of the regressors and of the dependent variable. The F. test reports the test of joint significance of all estimated coefficients. The Hansen test of overidentifying restrictions is reported. This test is robust to autocorrelation and heteroskedasticity of unknown form.

Table III: Structural parameters

| | All firms 1986-91 | All firms 1988-91 |
|---|---|---|
| $\widehat{\alpha}$ | 0.131 | 0.064 |
| $\widehat{\gamma}$ | 0.387 | 0.255 |
| $\widehat{\beta}$ | 0.497 | 0.640 |
| | | |
| $\widetilde{\alpha}$ | 0.040 | 0.043 |
| $\widetilde{\gamma}$ | 0.229 | 0.230 |
| $\widetilde{\beta}$ | 0.629 | 0.629 |

The estimates $\widehat{\alpha}$, $\widehat{\gamma}$ and $\widehat{\beta}$ are derived from the first two columns of table II, using the restrictions in equation (38). $\widetilde{\gamma}$ =average of (labour cost/output), $\widetilde{\beta}$=average of (materials cost/output), $\widetilde{\alpha}$ = average of (user cost of fixed capital/output). The user cost of fixed capital is computed by assuming that $\delta = 0.1$.

Table IV: Financing constraints test, direct and indirect criteria, 1986-91 sample.

Regression:

$$\ln l_{i,t} = \pi_0 + a_i + d_t + \pi_1 \ln \theta_{i,t} + \pi_2 \ln k_{i,t-1} + \pi_3 \ln n_{i,t} + \pi_4 \ln w^F_{i,t} + \varepsilon_{i,t}$$

| | Indirect Criteria | | | Direct criteria | |
|---|---|---|---|---|---|
| | $D^{age}$ | $D^{divpol}$ | $D^{size}$ | $\widehat{D}^{hs}$ panel | $\widehat{D}^{lc}$ panel |
| $\ln k_{i,t-1}$ | **0.32 (3.1)** | **0.27 (3.0)** | **0.26 (2.3)** | **0.27 (2.6)** | **0.21 (2.7)** |
| $\ln n_{i,t}$ | **0.66 (4.9)** | **0.65 (5.5)** | **0.70 (4.2)** | **0.61 (4.7)** | **0.67 (5.2)** |
| $\ln \theta_{i,t}$ | **2.31 (2.0)** | **4.01 (2.8)** | **3.65 (2.9)** | 3.02 (1.8) | **3.56 (2.6)** |
| $\ln w^F_{i,t}$ | -0.07 (-1.8) | -0.04 (-1) | -0.07 (-1.7) | 0.01 (0.2) | -0.05 (-1.5) |
| | | | | | |
| $\ln k_{i,t-1} {*} D_{i,t}$ | -0.32 (-1.7) | -0.16 (-1.1) | -0.08 (-0.4) | -0.07 (-1) | 0.03 (0.3) |
| $\ln n_{i,t} {*} D_{i,t}$ | -0.02 (-0.1) | 0.10 (0.6) | -0.10 (-0.5) | -0.13 (-1.2) | -0.34 (-1.7) |
| $\ln \theta_{i,t} {*} D_{i,t}$ | -0.85 (-0.3) | -3.99 (-1.5) | **-6.1 (-2.4)** | -3.29 (-1.2) | 2.88 (0.7) |
| $\ln w^F_{i,t} {*} D_{i,t}$ | **0.26 (2.5)** | 0.04 (0.6) | **0.20 (2.1)** | **0.22 (3.6)** | **0.15 (2.3)** |
| n. Obs. | 1666 | 1666 | 1666 | 1666 | 1666 |
| $F$ test | 25 (0.0) | 29 (0.0) | 32 (0.0) | 23 (0.0) | 13 (0.0) |
| *Hansen* test | 156 (175) | 195 (175) | 165 (175) | 219 ($269^1$) | 221 ($269^1$) |
| p-value | 0.840 | 0.136 | 0.690 | 0.989 | 0.985 |

The coefficients are estimated with a two step robust System GMM estimator (Blundell and Bond, 1998). The t-statistic is reported in parenthesis. Coefficients significant at the 95% confidence interval are in bold. See the footnote to table II for details. 1) the number of instruments is higher because we use as instruments all the variables interacted with the dummy variables for both the 1986-88 and the 1989-91 period.

Table V: Financing constraints test: direct revelation criteria and the 1988-91 sample. $\ln k_{i,t}$ and $\ln n_{i,t}$ as dependent variables.

| | $\ln n_{i,t}$ as dependent variable | | | $\ln k_{i,t}$ as dependent variable | | |
|---|---|---|---|---|---|---|
| | All firms | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ | All firms | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ |
| $\ln k_{i,t-1}$ | **.22 (3.1)** | **.22 (2.9)** | **.25 (3.2)** | | | |
| $\ln n_{i,t}$ | | | | 0.083 (0.6) | 0.005 (0.04) | 0.042 (0.3) |
| $\ln l_{i,t}$ | **.45 (5.9)** | **.45 (5.5)** | **.46 (5.6)** | **1.0 (6.5)** | **.92 (5.9)** | **1.1 (7.1)** |
| $\ln \theta_{i,t}$ | -0.52 (-0.7) | -0.56 (-0.6) | -0.42 (-0.5) | **-2.3 (-2.6)** | **-2.4 (-2.5)** | **-2.5 (-2.2)** |
| $\ln w^F_{i,t}$ | **.07 (3.3)** | **.07 (3.0)** | **.07 (3)** | -0.017 (-0.6) | -0.02 (-0.7) | -0.017 (-0.4) |
| $\ln k_{i,t-1}{*}D_{i,t}$ | | 0.14 (0.9) | 0.15 (1.2) | | | |
| $\ln n_{i,t}{*}D_{i,t}$ | | | | | **.42 (1.9)** | 0.043 (0.3) |
| $\ln l_{i,t}{*}D_{i,t}$ | | 0.13 (0.9) | -0.21 (-1.6) | | -0.33 (-1.3) | **-.65 (-2.6)** |
| $\ln \theta_{i,t} * D_{i,t}$ | | 0.93 (0.3) | **-4.6 (-2)** | | -0.81 (-0.1) | 2.78 (0.7) |
| $\ln w^F_{i,t}{*}D_{i,t}$ | | -0.03 (-0.4) | 0.07 (0.9) | | -0.14 (-1.0) | 0.073 (0.6) |
| n. Obs. | 1127 | 1127 | 1127 | 1122 | 1122 | 1122 |
| $F$ test | 23 (0.0) | 51 (0.0) | 14 (0.0) | 18 (0.0) | 24 (0.0) | 17 (0.0) |
| *Hansen* test | 76 (58) | 112 (117) | 134 (117) | 89 (58) | 125 (17) | 130 (117) |
| p-value | 0.059 | 0.617 | 0.130 | 0.006 | 0.289 | 0.196 |

The coefficients are estimated with a two step robust System GMM estimator (Blundell and Bond, 1998). The t-statistic is reported in parenthesis. Coefficients significant at the 95% confidence interval are in bold. See the footnote to table II for details.

Table VI: Financing constraints test: direct revelation criteria and the 1988-91 sample. Alternative definitions of wealth.

| Regression: $\ln l_{i,t} = \pi_0 + a_i + d_t + \pi_1 \ln \theta_{i,t} + \pi_2 \ln k_{i,t-1} + \pi_3 \ln n_{i,t} + \pi_4 \ln w_{i,t}^F + \varepsilon_{i,t}$ | | | | |
|---|---|---|---|---|
| | Using $\ln w_{i,t}^{Fnorm}$ | | Using $\ln \widetilde{w}_{i,t-1}^{Fnorm}$ | |
| | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ |
| $\ln k_{i,t-1}$ | 0.15 (1.6) | 0.07 (1.0) | 0.17 (1.7) | 0.20 (1.8) |
| $\ln n_{i,t}$ | **0.76 (4.4)** | **0.96 (7.2)** | **0.81 (5.6)** | **0.86 (6.5)** |
| $\ln \theta_{i,t}$ | **2.64 (2.9)** | **2.07 (2.1)** | **2.58 (3.0)** | **2.48 (2.4)** |
| $\ln w_{i,t}^F$ | **-0.17 (-2.4)** | -0.10 (1.7) | -0.09 (-1.1) | -0.15 (-1.5) |
| $\ln k_{i,t-1} {}^* D_{i,t}$ | -0.16 (-0.9) | -0.18 (-1.1) | -0.26 (-1.6) | **-0.46 (-2.6)** |
| $\ln n_{i,t} {}^* D_{i,t}$ | -0.16 (-0.6) | **-0.73 (-2.9)** | -0.23 (-1.1) | -0.41 (-1.7) |
| $\ln \theta_{i,t} {}^* D_{i,t}$ | -3.57 (-1.5) | 1.7 (0.5) | -3.26 (-1.3) | 2.51 (0.7) |
| $\ln w_{i,t}^F {}^* D_{i,t}$ | **0.57 (3.7)** | **0.82 (4.5)** | **0.58 (3.9)** | **0.86 (6.5)** |
| n. Obs. | 1412 | 1412 | 1429 | 1429 |
| $F$ test | 20 (0.0) | 22 (0.0) | 25 (0.0) | 19 (0.0) |
| *Hansen* test | 113 (114) | 130 (114) | 128 (114) | 138 (114) |
| p-value | 0.536 | 0.153 | 0.185 | 0.067 |

$w_{i,t}^{Fnorm}$ : it is a transformation of $w_{i,t,}^F$ that makes all observation positive. $\widetilde{w}_{i,t}^{Fnorm}$ : it is equal to $w_{i,t}^{Fnorm}$ but without inventories. The coefficients are estimated with a two step robust System GMM estimator (Blundell and Bond, 1998). The t-statistic is reported in parenthesis. Coefficients significant at the 95% confidence interval are in bold. See the footnote to table II for details.

Table VII: Financing constraints test: indirect criteria and the 1986-91 sample. Alternative definitions of wealth.

| Regression: $\ln l_{i,t} = \pi_0 + a_i + d_t + \pi_1 \ln \theta_{i,t} + \pi_2 \ln k_{i,t-1} + \pi_3 \ln n_{i,t} + \pi_4 \ln w^F_{i,t} + \varepsilon_{i,t}$ | | | | | | |
|---|---|---|---|---|---|---|
| | | $\ln w^{F\,norm}_{i,t}$ | | | $\ln \widetilde{w}^{F\,norm}_{i,t-1}$ | |
| | $D^{age}$ | $D^{divpol}$ | $D^{size}$ | $D^{age}$ | $D^{divpol}$ | $D^{size}$ |
| $\ln k_{i,t-1}$ | 0.13 (1.2) | **.22 (2.5)** | 0.20 (1.7) | 0.11 (0.9) | **.23 (2.3)** | 0.20 (1.8) |
| $\ln n_{i,t}$ | **.87 (6)** | **.69 (5.0)** | **.62 (4.1)** | **.85(5.6)** | **.57 (3.6)** | **.78 (4.5)** |
| $\ln \theta_{i,t}$ | 1.21 (1.1) | **3.6 (3.0)** | **2.8 (2.5)** | 1.21 (1.1) | **3.3 (2.7)** | **2.7 (2.7)** |
| $\ln w^F_{i,t}$ | -0.09 (-1.3) | -0.05 (-0.9) | -0.04 (-0.6) | -0.08 (-0.9) | -0.06 (-0.6) | -0.11 (-1.5) |
| $\ln k_{i,t-1}{*}D_{i,t}$ | -0.16 (-0.9) | -0.20 (-1.2) | -0.29 (-1.7) | -0.13 (-0.6) | -0.15 (-1) | **-.36 (-2.0)** |
| $\ln n_{i,t}{*}D_{i,t}$ | **-.55 (-2.7)** | -0.03 (-0.2) | **-.47 (-2.1)** | -0.45 (-1.8) | 0.17 (0.8) | **-.59 (-3.0)** |
| $\ln \theta_{i,t}{*}D_{i,t}$ | 1.86 (0.7) | -3.26 (-1.7) | -1.72 (-0.8) | 1.20 (0.5) | **-3.74 (-2)** | -3.1 (-1.4) |
| $\ln w^F_{i,t}{*}D_{i,t}$ | **.63 (3.8)** | 0.19 (1.6) | **.73 (5.8)** | **.50 (3.0)** | 0.26 (1.8) | **.82 (5.9)** |
| n. Obs. | 2102 | 2102 | 2102 | 2128 | 2128 | 2128 |
| $F$ test | 24 (0.0) | 22 (0.0) | 51 (0.0) | 23 (0.0) | 24 (0.0) | 52 (0.0) |
| *Hansen* test | 217 (175) | 215 (175) | 233 (175) | 239 (175) | 215 (175) | 197 (175) |
| p-value | 0.017 | 0.020 | 0.001 | 0.001 | 0.020 | 0.125 |

The coefficients are estimated with a two step robust System GMM estimator (Blundell and Bond, 1998). The t-statistic is reported in parenthesis. Coefficients significant at the 95% confidence interval are in bold. See the footnote to table II for details.

Table VIII: Financing constraints test: direct revelation criteria and the 1989-91 sample.

Regression:

$$\ln l_{i,t} = \pi_0 + a_i + d_t + \pi_1 \ln \theta_{i,t} + \pi_2 \ln k_{i,t-1} + \pi_3 \ln n_{i,t} + \pi_4 \ln w^F_{i,t} + \varepsilon_{i,t}$$

| | Using $\ln w^F_{i,t}$ | | Using $\ln w^{F\,norm}_{i,t}$ | | Using $\ln \widetilde{w}^{F\,norm}_{i,t-1}$ | |
|---|---|---|---|---|---|---|
| | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ |
| $\ln k_{i,t-1}$ | .031 (0.3) | .084 (0.9) | .20 (1.3) | .15 (1.2) | **.34 (2.4)** | .30 (1.8) |
| $\ln n_{i,t}$ | **.86 (4.0)** | **.74 (4.8)** | **.77 (3.5)** | **.91 (5.3)** | **.67 (3.8)** | **.71 (3.4)** |
| $\ln \theta_{i,t}$ | **3.1 (2.0)** | **2.5 (1.9)** | **3.4 (2.9)** | **2.8 (2.5)** | **3.7 (3.3)** | **3.4 (2.8)** |
| $\ln w^F_{i,t}$ | **-.12 (-2.0)** | **-.11 (-2.3)** | -.14 (-1.8) | **-.18 (-2.6)** | -.12 (-1.5) | **-.28 (-2.4)** |
| $\ln k_{i,t-1} * D_{i,t}$ | -.12 (-0.6) | -.13 (-0.6) | -.26 (-1.4) | -.33 (-1.6) | **-.48 (-2.3)** | **-.71 (-3.4)** |
| $\ln n_{i,t} * D_{i,t}$ | -.16 (-0.6) | -.46 (-1.3) | -.12 (-0.4) | **-.57 (-2.1)** | -.03 (-0.1) | -.28 (-1.1) |
| $\ln \theta_{i,t} * D_{i,t}$ | -3.3 (-0.7) | 7.2 (1.3) | -5.1 (-1.3) | 1.5 (0.3) | -5.6 (-1.3) | 3.3 (0.6) |
| $\ln w^F_{i,t} * D_{i,t}$ | **.36 (2.9)** | **.28 (2.7)** | **.51 (2.9)** | **.81 (4.9)** | **.46 (2.5)** | **.89 (4.3)** |
| n. Obs. | 841 | 841 | 1056 | 1056 | 1070 | 1070 |
| $F$ test | 15 (0.0) | 12 (0.0) | 13 (0.0) | 22 (0.0) | 13 (0.0) | 17 (0.0) |
| *Hansen* test | 77 (86) | 78 (86) | 93 (86) | 99 (86) | 97 (86) | 106 (86) |
| p-value | 0.732 | 0.725 | 0.289 | 0.1570 | 0.185 | 0.074 |

The coefficients are estimated with a two step robust System GMM estimator (Blundell and Bond, 1998). The t-statistic is reported in parenthesis. Coefficients significant at the 95% confidence interval are in bold. See the footnote to table II for details.

Table IX: Financing constraints test: the Euler equation approach

Regression:

$$\left(\frac{i}{k}\right)_{i,t} = \beta_1 \left(\frac{i}{k}\right)_{i,t-1} + \beta_2 \left(\frac{i}{k}\right)^2_{i,t-1} + \beta_3 \left(\frac{cf}{k}\right)_{i,t-1} + \beta_4 \left(\frac{y}{k}\right)_{i,t-1} + \beta_5 \left(\frac{b}{k}\right)_{i,t-1}$$

| | 1988-91 sample | | | 1986-91 sample | | |
|---|---|---|---|---|---|---|
| | All firms | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ | $D^{age}$ | $D^{size}$ | $D^{divpol}$ |
| $\left(\frac{i}{k}\right)_{i,t-1}$ | **.17 (2.1)** | 0.15 (1.9) | 0.14 (1.7) | 0.13 (1.7) | 0.04 (0.5) | 0.06 (0.8) |
| $\left(\frac{i}{k}\right)^2_{i,t-1}$ | -0.09 (-1.3) | -0.09 (-1.4) | -0.08 (-1.2) | -0.08 (-1.3) | -0.03 (-0.4) | -0.03 (-0.4) |
| $\left(\frac{cf}{k}\right)_{i,t-1}$ | **.18 (3.4)** | 0.10 (1.6) | **.16 (2.2)** | 0.06 (1.1) | **.11 (2.0)** | **.14 (2.2)** |
| $\left(\frac{y}{k}\right)_{i,t-1}$ | 0.007 (1.7) | **.015 (2.3)** | 0.013 (1.7) | 0.01 (1.9) | **.02 (3.2)** | 0.01 (1.4) |
| $\left(\frac{b}{k}\right)_{i,t-1}$ | -0.19 (-1) | -0.033 (-1) | -0.001 (-0.04) | 0.01 (0.3) | 0.01 (0.5) | 0.02 (0.8) |
| $\left(\frac{i}{k}\right)_{i,t-1} * D_{i,t}$ | | -0.099 (-0.5) | -0.12 (-0.7) | -0.17 (-1.1) | 0.12 (0.8) | 0.15 (1.2) |
| $\left(\frac{i}{k}\right)^2_{i,t-1} * D_{i,t}$ | | 0.089 (0.6) | 0.10 (0.7) | 0.12 (1.0) | -0.11 (-0.9) | -0.13 (-1.2) |
| $\left(\frac{cf}{k}\right)_{i,t-1} * D_{i,t}$ | | 0.21 (1.7) | 0.08 (0.7) | 0.15 (1.8) | 0.02 (0.2) | -0.03 (-0.4) |
| $\left(\frac{y}{k}\right)_{i,t-1} * D_{i,t}$ | | 0.003 (0.3) | 0.0004 (0.03) | 0.002 (0.2) | -0.01 (-1) | -0.01 (-0.7) |
| $\left(\frac{b}{k}\right)_{i,t-1} * D_{i,t}$ | | 0.012 (0.3) | -0.03 (-0.9) | 0.04 (1.0) | -0.04 (-0.9) | -0.04 (-0.8) |
| N. obs. | 1392 | 1392 | 1392 | 2095 | 2095 | 2095 |
| $F$ test | 6.73 (0.0) | 7.4 (0.0) | 4.7 (0.0) | 4.1 (0.0) | 6.0 (0.0) | 4.8 (0.0) |
| $Hansen$ test | 46 (56) | 99 (115) | 108 (115) | 145 (177) | 154 (177) | 176 (177) |
| p-value | 0.808 | 0.842 | 0.654 | 0.961 | 0.887 | 0.502 |
| | Only positive wealth | | | | | |
| $\left(\frac{cf}{k}\right)_{i,t-1}$ | 0.13 (2.1) | 0.08 (1.1) | 0.13 (1.7) | 0.07 (1.2) | 0.12 (1.9) | 0.09 (1.4) |
| $\left(\frac{cf}{k}\right)_{i,t-1} * D_{i,t}$ | | 0.22 (1.4) | 0.15 (1.0) | 0.15 (1.6) | -0.06 (-0.5) | 0.05 (0.5) |
| N. obs. | 1156 | 1156 | 1156 | 1745 | 1745 | 1745 |

The coefficients are estimated with a two step robust System GMM estimator (Blundell and Bond, 1998). The t-statistic is reported in parenthesis. Coefficients significant at the 95% confidence interval are in bold. The smallest and largest 1% of the observations of each variable are eliminated as outliers. See the footnote to table II for details.

Table X: Euler equation approach. Alternative specifications

Regression:

$$\left(\frac{i}{k}\right)_{i,t} = \beta_1 \left(\frac{i}{k}\right)_{i,t-1} + \beta_2 \left(\frac{i}{k}\right)^2_{i,t-1} + \beta_3 \left(\frac{w}{k}\right)_{i,t-1} + \beta_4 \left(\frac{y}{k}\right)_{i,t-1} + \beta_5 \left(\frac{b}{k}\right)_{i,t-1}$$

| | 1988-91 sample | | | 1986-91 sample | | |
|---|---|---|---|---|---|---|
| | All firms | $\widehat{D}^{hs}$ | $\widehat{D}^{lc}$ | $D^{age}$ | $D^{size}$ | $D^{divpol}$ |
| $\left(\frac{i}{k}\right)_{i,t-1}$ | 0.098 (1.6) | 0.13 (1.4) | 0.045 (0.5) | 0.053 (0.7) | -0.01 (-0.1) | 0.05 (0.7) |
| $\left(\frac{i}{k}\right)^2_{i,t-1}$ | -0.020 (-0.4) | -0.021 (-0.3) | 0.044 (0.6) | -0.004 (-0.1) | 0.03 (0.5) | -0.017 (-0.3) |
| $\left(\frac{w^F}{k}\right)_{i,t-1}$ | 0.005 (0.4) | 0.01 (0.7) | 0.002 (0.2) | 0.003 (0.3) | 0.01 (0.8) | 0.004 (0.4) |
| $\left(\frac{y}{k}\right)_{i,t-1}$ | **.012 (2.9)** | **.015 (2.5)** | **.020 (3.1)** | **.014 (2.6)** | **.024 (4.4)** | **.018 (3.0)** |
| $\left(\frac{b}{k}\right)_{i,t-1}$ | -0.011 (-0.7) | **-.05 (-2.1)** | -0.02 (-0.7) | -0.003 (-0.2) | -0.01 (-0.4) | 0.017 (0.7) |
| $\left(\frac{i}{k}\right)_{i,t-1} * D_{i,t}$ | | -0.078 (-0.4) | 0.043 (0.2) | -0.04 (-0.3) | 0.11 (0.6) | 0.089 (0.7) |
| $\left(\frac{i}{k}\right)^2_{i,t-1} * D_{i,t}$ | | 0.096 (0.7) | -0.013 (-0.1) | 0.011 (0.1) | -0.095 (-0.7) | -0.018 (-0.2) |
| $\left(\frac{w^F}{k}\right)_{i,t-1} * D_{i,t}$ | | **.042 (2.3)** | 0.031 (1.1) | -0.018 (-1.3) | -0.016 (-1) | 0.009 (0.6) |
| $\left(\frac{y}{k}\right)_{i,t-1} * D_{i,t}$ | | 0.01 (0.9) | -0.001 (-0.1) | 0.01 (0.8) | -0.011 (-1.6) | -0.10 (-1.2) |
| $\left(\frac{b}{k}\right)_{i,t-1} * D_{i,t}$ | | 0.032 (0.7) | -0.01 (-0.1) | 0.04 (1.1) | -0.05 (-1.2) | -0.034 (-1.1) |
| N. obs. | 1323 | 1323 | 1323 | 1987 | 1987 | 1987 |
| $F$ test | 6.0 (0.0) | 9.0 (0.0) | 4.8 (0.0) | 3.5 (0.0) | 5.2 (0.0) | 4.7 (0.0) |
| $Hansen$ test | 86 (86) | 110 (115) | 115 (115) | 161 (177) | 155 (177) | 184 (177) |
| p-value | 0.483 | 0.621 | 0.483 | 0.798 | 0.876 | 0.329 |
| | Only positive wealth | | | | | |
| $\left(\frac{w^F}{k}\right)_{i,t-1}$ | -0.002 (-0.2) | 0.0003 (0.03) | -0.003 (-0.3) | -0.002 (-0.2) | -0.002 (-0.2) | -0.01 (-0.6) |
| $\left(\frac{w^F}{k}\right)_{i,t-1} * D_{i,t}$ | | 0.032 (1.1) | 0.036 (0.9) | -0.012 (-0.8) | -0.005 (-0.3) | 0.021 (1.2) |
| N. obs. | 1114 | 1114 | 1114 | 1114 | 1114 | 1114 |

The coefficients are estimated with a two step robust System GMM estimator (Blundell and Bond, 1998). The t-statistic is reported in parenthesis. Coefficients significant at the 95% confidence interval are in bold. The smallest and largest 1% of the observations of each variable are eliminated as outliers. See the footnote to table II for details.

Table XI: Summary statistics of the variables used to estimate the production function

| Variable | Mean | St.Dev | Min | Max |
|---|---|---|---|---|
| $y_{i,t}$ | 33.105 | 68.002 | 1.095 | 1162.078 |
| $l_{i,t}$ | 19.582 | 51.121 | 0.093 | 1200.405 |
| $n_{i,t}$ | 11.303 | 19.475 | 0.343 | 235.296 |
| $k_{i,t}$ | 8.179 | 18.454 | 0.067 | 259.543 |

Values are in billions of Italian Liras, 1982 prices. 1 Billion liras was equal to 0.71 million US$ at the 1982 exchange rate. $y_{i,t}$ = total revenues; $k_{i,t}$ = replacement value of the plant, equipment and other intangible fixed assets; $l_{i,t}$ = usage of materials; $n_{i,t}$ = labour cost.

Table XII: Composition of the groups for which the production function is separately estimated.

| **Two Digits ISTAT* Sectors** | **Number of firms** |
|---|---|
| Group 1: Industrial Machinery | 78 |
| Group 2: Electronic Machinery, Precision Instruments | 49 |
| Group 3: Textiles, Shoes and Clothes, Wood Furniture | 117 |
| Group 4: Chemicals, Rubber and Plastics | 63 |
| Group 5: Metallic Products | 80 |
| Group 6: Food, Sugar and Tobaccos, Paper and Printing | 66 |
| Group 7: Non-metallic Minerals, Other Manufacturing | 108 |

* Italian National Statistic Institute

Table XIII: Production function estimation results.

| | All Firms | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group6 | Group 7 |
|---|---|---|---|---|---|---|---|---|
| $\widehat{\alpha}$ | 0.111 | 0.105 | 0.062 | 0.114 | 0.081 | 0.038 | 0.040 | 0.198 |
| | (0.02) | (0.02) | (0.015) | (0.03) | (0.02) | (0.022) | (0.01) | (0.02) |
| $\widehat{\beta}$ | 0.389 | 0.377 | 0.289 | 0.424 | 0.454 | 0.393 | 0.562 | 0.406 |
| | (0.02) | (0.01) | (0.013) | (0.03) | (0.01) | (0.017) | (0.01) | (0.024) |
| $\widehat{\gamma}$ | 0.441 | 0.494 | 0.468 | 0.348 | 0.193 | 0.491 | 0.350 | 0.401 |
| | (0.03) | (0.02) | (0.023) | (0.04) | (0.01) | (0.034) | (0.01) | (0.05) |
| Sargan T. | 65.50 | 38.90 | 25.78 | 39.87 | 39.71 | 38.20 | 45.18 | 33.64 |
| D.f. | 37 | 37 | 27** | 37 | 37 | 37 | 36* | 36* |
| P-value | 0.00 | 0.38 | 0.53 | 0.34 | 0.35 | 0.40 | 0.14 | 0.58 |
| $\chi^{2***}$ | | 29.7 | 41.7 | 814.6 | 217.2 | 9.61 | 11.35 | 0.01 |
| p-value | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.91 |
| n. firms | 561 | 78 | 49 | 117 | 63 | 80 | 66 | 108 |
| n. obs. | 4488 | 624 | 392 | 936 | 504 | 640 | 528 | 864 |

* One coefficient relative to a two-digit sector dummy variable is estimated here. ** Only $t-1$ instruments used for the estimation of this group, due to the reduced number of observations. *** Wald test of the following restriction: $\alpha+\beta+\gamma=1$. Standard deviations are in parenthesis. $\widehat{\alpha}$ = estimated elasticity of output to fixed capital. $\widehat{\beta}$ = estimated elasticity of output to variable capital. $\widehat{\gamma}$ = estimated elasticity of output to labour. Sargan test is a test of the overidentifying restrictions.

Table XIV: Test of the validity of the instruments.

| $\ln l_{i,t} = \pi_1 \ln \theta_{i,t} + \pi_2 \ln k_{i,t-1} + \pi_3 \ln n_{i,t} + \pi_4 \ln w^F_{i,t}$ | | | |
|---|---|---|---|
| | t-1 to t-3 first differences[1] as instruments of the levels eq. | t-2 to t-3 levels as instruments of the equation in first differences | t-3 to t-4 levels as instruments of the equation in first differences |
| *Hansen J* statistic (p-value) - cross sectional equations | | | |
| 1986 | 0.34 | 0.67 | |
| 1987 | 0.46 | 0.03 | 0.87 |
| 1988 | 0.81 | 0.53 | 0.89 |
| 1989 | 0.51 | 0.58 | 0.66 |
| 1990 | 0.27 | 0.51 | 0.67 |
| 1991 | 0.93 | 0.03 | 0.11 |
| First stage regressions statistics | | | |
| $\ln k_{i,t-1}$ : Shea's partial $R^2$ | 0.01 | 0.13 | 0.07 |
| $\ln k_{i,t-1}$ : F stat. (p-val.) | 1 (0.60) | 24 (0.000) | 10 (0.000) |
| $\ln n_{i,t}$ : Shea's partial $R^2$ | 0.025 | 0.05 | 0.03 |
| $\ln n_{i,t}$ : F stat. (p-value) | 1.1 (0.37) | 10 (0.000) | 5.4 (0.000) |
| $\ln w^F_{i,t}$ : Shea's partial $R^2$ | 0.16 | 0.16 | 0.01 |
| $\ln w^F_{i,t}$ :F stat. (p-value) | 5.2 (0.000) | 20 (0.000) | 2.3 (0.013) |
| $\ln \theta_{i,t}$ :Shea's part. $R^2$ | 0.44 | 0.31 | 0.05 |
| $\ln \theta_{i,t}$ :F stat. (p-val.) | 60.4 (0.000) | 44 (0.000) | 12 (0.00) |

1) We include the first differences of the regressors and the t-2 and t-3 first differences of the dependent variable.