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INVESTMENT AND FINANCIAL STRUCTURE IN SPANISH MANUFACTURING FIRMS

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This paper analyses empirically the interrelatedness of investment and financial variables within a non linear Euler equation setup. The neoclassical model of investment is rejected due to its correlation with financial variables. Alternatively, an investment model in which there is a premium on the cost of external funds is accepted. This premium depends on the debt level and the asset structure of the firms. For small firms, because of their financial characteristics, we accept an investment model for which the cost of external funds is increasing and convex. This implies, for the case of Spanish manufacturing firms, an average premium of 1.9 percentage points above the risk free interest rate. (*JEL* E22, G31, G32)

1. Introduction

The interrelatedness of investment and financing decisions has been the subject of empirical work not only at the aggregate level but also at the firm level. One of the theoretical explanations for the rationing of, or the premium on the cost of, external funds is the existence of asymmetrical information (see Stiglitz and Weiss (1981) and Calomiris and Hubbard (1990)). If this is the case, the quantity or the cost of the debt for the firms will depend on observable characteristics that are proxies for the risk of, or the expected return on, their investment projects. We test the significance of such an interrelationship in a non linear set up with a panel of firms.

In the literature we find two alternative structural models to study the above empirical questions. We could estimate the investment equation derived from a profit maximization problem and relate it to the "Q"

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or shadow price of the capital stock (Hayashi (1982)). Adding to the model a variable that measures the availability of financial resources (i.e. cash-flow), financially constrained firms are identified with those for which the financial variable is significant (Fazzari et al. (1988)). The usual critique to this approach arises from the difficulty of measuring the Q variable, therefore the financial variables coefficient may be taking into account a different effect such as future investment opportunities[1].

The other structural model uses the investment relationship between two consecutive periods that arises from the first-order conditions of the firm optimization problem. In the presence of either a restriction on the amount of debt borrowed or an elastic supply function of external funds investment demand may depend on variables other than relative prices and output. Whited (1992), using firm level data, modelled the shadow price of a restriction on the limit of debt as a function of observable variables. We follow Bond and Meghir (1994) considering the endogeneity of such a relationship by setting a supply function of funds, known to the firm, that depends on certain characteristics of the firm. Nevertheless we do not deal with the identification problem of which is the source of imperfect information, neither we discuss about the efficiency of the observed level of investment.

As a first objective of the paper we test the influence of financial variables on investment decisions within a neoclassical framework in which all the firms face the same marginal cost of debt. We reject a non linear adjustment cost model in which investment projects take one period to become productive, interest rates are variable and the cash-flow exactly measures the marginal productivity of capital. We also find that the source of that rejection is the correlation of investment disturbances with financial variables. This is consistent with the "excess sensitivity" of firm investment to measures of internal finance found by Bond and Meghir in a linear setup for U.K. data.

As a second objective we accept an alternative model with a elastic credit supply function of the current level of external funds and the

[1] Fazzari and Petersen (1993) have defended this procedure once it is controlled by a variable that takes account of shifts in the demand for investment. Nevertheless, more recently, Kaplan and Zingales (1997) have shown that the higher sensitivity to cash-flow cannot be interpreted as evidence that those firms are more financially constrained.

asset structure. Within that framework we are able to recover the structural parameters of the model and quantify the importance of some of the firms' financial characteristics. Thirdly, we also look for evidence of groups of firms that are financially constrained because of risk concentration, lack of collateral or the high costs of alternative financial sources. We found that our alternative model implies, for presample chosen small firms, a higher premium cost of external funds.

Our empirical work is made with a panel of Spanish manufacturing firms in the period 1984-1992. The study of such financing/investment relationships in Spanish firms may be interesting for two reasons. Spanish financial markets are much less developed than in countries like UK or US. Stock and private debt markets are very small, so financial institutions (mostly banks) play an important role, as in Japan or Germany, and become the main source of the firms' external funds, most of which are due in the short run. Nevertheless, during the expansionary period analyzed, with interest rates at extremely high levels, Spanish firms, on average, decreased their debt-to-total-assets ratio and raised the ratio of liquid assets to total debt. This was possible because firms kept a high level of cash-flow, and it did not prevent a high increase in investment in the economy (from 11% of GDP in 1984 to 16% in 1990 and 15% in 1992). We would expect in such a economy with a small financial system but large changes in investment that financial and investment decisions were highly correlated. When banks are the supplier of external funds, so that firm screening is higher, the firm's distribution of assets should be as important as the debt position to obtain the funds that finance investment. Moreover, the relevance of collateral and bankruptcy risk in the determination of financial cost could help explain the differences on the cyclical behaviour of investment and other real variables in response to monetary and fiscal shocks (see, for example, Gertler and Gilchrist (1994)).

The second section presents, firstly, a model of investment demand and, secondly, the alternative model. In the third section we analyze the sample information and the estimation procedure. The fourth section contains the estimation results and the fifth section draws conclusions.

2. Theoretical framework

2.1 A neoclassical model of investment

Each firm maximizes the discounted present value of dividends (d_{it})

$$Max\ E_0 \sum_{t=1}^{\infty} \left(\prod_{s=0}^{t-1} \beta_{is} \right) d_{it} \qquad [1]$$

where β_{is} is the discount factor for the firm i in period s[2]. The firms solve [1] subject to two restrictions, one financial and the other technological.

The financial restriction determines the three possible uses of the firm's resources: debt payments (B_{-1}), dividends or additions to capital. These internal resources cannot be negative ($d \geq 0$), i.e. new equity is not considered as a source of funds[3].

Let K_{-1} be the stock of capital in the current period, I gross investment, N the labor and WN the nominal labor costs. The production function is given by $F(K_{-1}, N)$. There are adjustment costs of investment in terms of forgone output represented by the function $H(I, K_{-1})$. In each period the firm has to meet the requirement that the sum of internal resources and debt payments should be equal to production less the cost of adjusting the investment, the cost of labor and the cost of investment. Each firm is a price-taker in the factor markets but faces monopolistic competition in the output market. The known demand function for each firm is assumed to be $P_{it} = Y_{it}^{-1/\epsilon} = (F_{it} - H_{it})^{-1/\epsilon}$ where ε is the price elasticity common to all firms.

Therefore, firm i must satisfy, in each period, the following equality in nominal terms:

$$\begin{aligned} d_{it} = (1-\tau)[P_{it}F(K_{it-1}, N_{it}) - W_{it}N_{it} - P_{it}H(I_{it}, K_{it-1}) \\ -r_{t-1}B_{it-1}] + B_{it} - B_{it-1} - P_{it}^{I} I_{it}, \end{aligned} \qquad [2]$$

where τ is the profit tax, r_{t-1} is the nominal interest rate on the debt and P_{it}^{I} is the effective price of the investment goods (corrected by the

[2] In this model firms are risk-neutral. Thus, we suppose that the relationship between investment and financing does not necessarily reflect risk aversion.

[3] The number of firms that increase their capital in the sample is small and their volume is not significant. In any case, those firms are not dropped in the estimation.

investment tax allowances). Note that I and K are defined in real terms whereas B is defined in nominal terms.

The technological restriction, associated with the rule of capital accumulation is

$$K_{it} = I_{it} + (1 - \delta_i)K_{it-1}. \qquad [3]$$

The stock of capital in each firm (evaluated at the end of each period) is subject to a fixed depreciation rate of (δ_i). This accumulation rule of capital, combined with the production function definition, means that investment takes one period to become productive[4].

We also impose the usual transversality condition, which prevents firms from borrowing an unlimited amount:

$$\lim_{T\to\infty} \left(\prod_{s=0}^{T-1} \beta_{is}\right) B_{it} = 0. \qquad [4]$$

Let $\emptyset_{it}$ be the multiplier associated with the restriction of non-negativity of dividends

$$d_{it} \geq 0. \qquad [5]$$

Given the stock of capital K_{it-1} and knowing the set of factor prices, the firm chooses the vector $(K_{it}, I_{it}, N_{it}, B_{it})$ that maximizes [1] given the restrictions [2], [3], [4] and [5]. Once we substitute [3] into [2], the first-order conditions with respect to labor, capital and debt are:

$$N_{it} \ : \ (1 - 1/\epsilon)F_{Nit} = \frac{W_{it}}{P_{it}}. \qquad [6]$$

$$\begin{aligned} K_{it} \ : \ & \beta_{it}E_t\{\frac{1+\phi_{it+1}}{1+\phi_{it}}[(1-1/\epsilon)P_{it+1}F_{Kit+1} + \\ & (1-1/\epsilon)(1-\delta_i)P_{it+1}H_{Iit+1} - \\ & (1-1/\epsilon)P_{it+1}H_{Kit+1} + (1-\delta_i)\frac{1}{(1-\tau)}P^I_{it+1}]\} - \qquad [7] \\ = \ & (1-1/\epsilon)P_{it}H_{Iit} - \frac{1}{(1-\tau)}P^I_{it} = 0. \end{aligned}$$

$$B_{it} \ : \ (1 + \phi_{it}) - \beta_{it}E_t\{[(1-\tau)r_t + 1](1 + \phi_{it+1}) = 0. \qquad [8]$$

The first condition shows that the price for the labor factor is equal to its marginal productivity. The second condition indicates that the current value of one unit of investment must be equal to its expected

[4]In an aggregate economy, Kydland and Prescott (1982) verify the empirical relevance of this assumption.

yield for each firm. Expression [8] says that when the internal resources are strictly positive the discount rate of each firm must be equal to the inverse of the market interest rate that we consider to be known by the agents.

In order to obtain an optimal investment rule for estimation, we must choose some functional forms for F and H. F is assumed to be homogenous of degree one, so that, the marginal productivity of capital is $F_K = (F - NF_N)/K = CF/K$[5]. CF represents the cash-flow or resources generated after the payment of variable inputs. If F were not homogeneous of degree one we could not identify in our econometric exercise returns to scale from market power.

The adjustment cost function, H, is positive and convex in gross investment, indicating that more investment implies higher costs for the firm. The function is modelled in terms of deviations with respect to a constant rate of investment c, α being the adjustment cost parameter.

$$H = \frac{\alpha}{2}\left(\frac{I_{it}}{K_{it-1}} - c\right)^2 K_{it-1}. \qquad [9]$$

If the restriction of dividends (d_{it}) is satisfied with strict inequality, β_{it} is equal to the inverse of the interest rate. If not, we assume that the conditional covariance between the shadow price of this restriction $(\emptyset_{it+1})$ and the variables in $(t+1)$ is constant. Therefore, in both cases, we arrive at the following rule of optimal investment:

$$\begin{aligned} & \frac{1}{(1-\tau)r_t + 1}\left(\frac{P_{it+1}}{P_{it}}\right) E_t\{\frac{CF_{it+1}}{K_{it}} - 1/\epsilon\frac{Y_{it+1}}{K_{it}} \\ - \quad & (1-1/\epsilon)H_K(K_{it}, I_{it+1}) + (1-\delta_i)[(1-1/\epsilon)H_I(K_{it}, I_{it+1}) \\ + \quad & p^I_{it+1}]\} - (1-1/\epsilon)H_I(K_{it-1}, I_{it}) - p^I_{it} = 0. \qquad [10] \end{aligned}$$

Where we have defined $p^I_{it} = \frac{1}{(1-\tau)}\frac{P^I_{it}}{P_{it}}$. This investment function is non-linear in the change in investment prices and in the level of cash-flow which measures the marginal productivity of capital (see Sargent (1979) for a linear case). In general, we expect that the demand for investment will be negatively correlated with both variables. Monopolistic competition generates an additional term, the output per unit of capital, which will positively affect the demand for investment. Under rational expectations, the bracket terms in [10] may be substituted out

[5] Hernando and Vallés (1994) accepted the hypothesis of constant returns to scale for a sample of Spanish manufacturing firms similar to the one used here.

by their observed values, adding to the Euler equations an expectations error with zero mean and uncorrelated with all the variables in the information set of the firm at period $t(E(e_{it+1}|\Omega_{it}) = 0)$.

To obtain the above investment equation we made certain assumptions about the behaviour of dividends that is related to the independence of investment and financial decisions[6]. As an initial test of such independence, we check whether the expectations error of the investment equation is equally correlated with financial and non-financial variables. Secondly, we develop an alternative model of investment that takes into account explicitly the interrelation of both decisions.

2.2 Relationship between investment and financing

In a partial equilibrium model such as that developed above there are two ways in the literature to impose the existence of an additional restriction between suppliers and demanders of credit. One is to fix a limit on the amount of debt each firm may borrow in each period of time. See, for example, Whited (1992) with individual information, and Hubbard and Kashyap (1992) with aggregate data. That type of models, like the previously comment Q models, do not carefully derive the relationship between investment and financing from an explicit model (see Chirinko (1993)).

The second way is to make it so that the cost of external funds depends, in each period, on observable characteristics of the firm such as the level of previous debt and its collateral. If the collateral of a firm is lower than its stock of debt, there will be a positive probability of bankruptcy and then the supply of funds will be linear in the non-risk interest rate, increasing in the debt-to-stock of capital ratio and decreasing in the fraction of assets that may be recovered without cost by the borrowers[7].

In the presence of a credit market with a high proportion of credit from the banking system (as is the case in Spain) and information asymmetries, the firms that maintain a certain level of liquid assets, in

[6] If $\emptyset_{it+1} > 0$ and its conditional covariance with $(t+1)$ variables is not a constant, the investment equation [10] will include, besides the expectational error, the expectational error of the indebtedness level, equation [8], multiplied by the $(t+1)$ variables.

[7] Adding as a decision variable the liquid assets with a price equal to the non-risk interest rate implies a new condition in which the intertemporal discount rate of the firm is equal to the inverse of the interest rate.

the form of current accounts for example, will affect the cost of credit. A good portion of debt contracts are associated with the existence of collateral such as mortgages or guaranteed credits. Following Bond and Meghir (1994), Alonso (1994) and Johansen (1994) we set a credit function, known to the firm, elastic to certain characteristics of the firm. Contrary to them, in our non linear environment, we impose that the argument of such a function (B_{it}) is not the level of gross debt but the level of net debt defined as gross debt minus liquid assets per unit of capital:

$$r_{it} = r_t + G(B_{it}, K_{it}), \qquad [11]$$

where

$$G = b\frac{B_{it}}{P^I_{it}K_{it}}$$

or

$$G = b_1\frac{B_{it}}{P^I_{it}K_{it}} + b_2\frac{B^2_{it}}{(P^I_{it}K_{it})^2}.$$

We try two functional forms for G. The first one has a linear form where b has to be positive. The second one has a quadratic form, it is similar to the one used by Whited, and tries to test if a large ratio of net debt to capital has a much greater effect for financing investment than a small ratio. For this relation to hold the values of b_1 and b_2 need to be positive (a convex function). Our framework allows us to test the statistical significance of finance constraints throughout the b estimates.

Including [11] as a known function in the optimization problem of the firm we obtain the following investment relationship:

$$\begin{aligned}&\frac{1}{(1-\tau)[r_t + G_B(B_{it}K_{it})B_{it}] + 1}\left(\frac{P_{it+1}}{P_{it}}\right) Et[\frac{CF_{it+1}}{K_{it}} - \\ &1/\epsilon\frac{Y_{it+1}}{K_{it}} - (1-1/\epsilon)H_K(K_{it}, I_{it+1}) - G_K(B_{it}, K_{it})B_{it} - \qquad [12] \\ &(1-\delta_i)((1-1/\epsilon)H_I(K_{it}, I_{it+1}) - \\ &p^I_{it+1})] - (1-1/\epsilon)H_I(K_{it-1}, I_{it}) - p^I_{it} = 0.\end{aligned}$$

To obtain [12] we have made the same assumptions about the behaviour of the shadow price of the internal resources condition as in the case of an inelastic interest rate function. Nevertheless, in this case we think that the expectation error associated with the optimal debt level (equation [8]) will not be correlated with financial variables because we have already included such a relationship in the investment decision through [11].

If the firm faces not an elastic interest rate but a limit on the level of debt it may borrow, then the expected term of the investment function will also be premultiplied by an additional factor as in [12]. Whited (1992) considers such a restriction and models this additional factor (the shadow price of the debt limit) in terms of financial characteristics of the firm. The difference with this approach is that in our case the firm knows the interest rate is a function of certain decision variables, so that firm actions may influence its interest rate.

3. Sample information and estimation method

3.1 Sample information

We have an unbalanced panel of 1508 Spanish manufacturing firms for the period 1983-1992. The data appendix describes the sample from the Banco de España Central Balance Sheet Office (CBBE), the construction of the variables and some sample statistics.

The capital stock series have been obtained using the perpetual inventory method with a constant sectorial depreciation rate (δ_j) taken from Hulten and Wykoff (1981) and a sectoral deflator. Since gross investment is defined as the changes in net fixed capital and not as the sum of capital expenditures within a period, it may take negative values for some firms.

Output in each firm is value added, i.e. the value of sales less intermediate inputs. Cash-flow is the difference between value added and labour expenditures. The economic value of the debt is set equal to its book value since most of it is due in the short-run (less than a year) and there is no information about its maturity date. Liquid assets are short-run financial assets plus current accounts and cash.

Given the large number of firms in the sample and the possible differences in their accounting methods, the variance of the variables from firm to firm is high, especially in the stock of capital (see table A.2). The prices are time series with sectoral and aggregate variation[8]. Interest rates, equal for all the firms, correspond to a long-term asset without risk, government bonds. Output prices are equal to the sectoral value-added deflators. Investment goods prices are also sectoral.

[8] Except the labor costs that have also individual variation.

3.2 Estimation method

The Euler equation [10] of the investment model that assumes its independence from the financial variables, once we incorporate the expectation error, is:

$$\frac{1}{(1-\tau)r_t+1}\frac{P_{jt+1}}{P_{jt}}\left[\frac{CF_{it+1}}{K_{it}} - 1/\epsilon\frac{Y_{it+1}}{K_{it}} + \frac{\alpha}{2} - (1-1/\epsilon)\left(\frac{I_{it+1}}{K_{it}}\right)^2 + \alpha(1-1/\epsilon)(1-\delta_j)\frac{I_{it+1}}{K_{it}}\right] - \alpha(1-1/\epsilon)\frac{I_{it}}{K_{it+1}} + \frac{1}{(1-\tau)r_t+1}\frac{P_{jt+1}}{P_{jt}}\left[(1-\delta_j)p^I_{jt+1} - \alpha(1-1/\epsilon)\left(\frac{\delta_j^2}{2}-\delta_j\right)\right] + \alpha(1-1/\epsilon)\delta_j - p^I_{jt} = e_{it+1}. \quad [13]$$

In that expression we have substituted out the unobservable constant parameter c of the adjustment cost function by the replacement level of investment δ_j. We also consider the existence of additive individual effects (a_i) which try to measure differences between firms in their technological processes (either in factor intensity or in the adjustment cost of capital), in market structure (for example, their elasticity of demand), in the technological changes they adopt or in the covariance term between the shadow price of internal resources and variables in $(t+1)$. The time dummies (a_t) will also correct for cyclical effects in investment demand that are not incorporated by the interest rate variable. The last three terms of [13] only present sectoral and time variation. Given that the small sectoral variation of investment prices and depreciation in our sample produced very poor parameter estimates, those terms have been eliminated and approximated by independent time (a_t) and sectoral (a_j) dummies in the first differences equation.

The investment demand function is not linear in the variables and in the structural parameters. The estimation procedure is the generalized method of moments (GMM, Hansen (1982))[9]. For a given set of instruments, the method finds the set of estimators that satisfy the orthogonality conditions that the expectations error e_{it+1} must fulfil. The instruments are variables in the information set of the firms at period t, correlated with the variables that appear in the investment

[9] We use a modified version of a GAUSS program written by Hansen, Heaton and Ogaki.

equation. In general, the instruments used are lagged variables of those variables.

Since we have included fixed effects that may be correlated with the contemporaneous variables in the investment demand function, we eliminate them estimating in first differences. Now the expectation error will be a moving average of order one and, therefore, the valid instruments are variables in $(t-1)$. We also take into account the existence of a MA(1) error term to correct the estimated covariance matrix of the orthogonality conditions (see Runkle (1991))[10]. Since the panel is unbalanced we only consider the existing cross products for each firm.

We obtain estimated values of the adjustment cost parameter (α) and the elasticity of demand function (ϵ). On the basis of the orthogonality conditions we also test the acceptance of the neoclassical investment model and analyze whether that depends on the error term correlation with financial variables.

We also estimate the alternative model in which financial variables affect investment through an elastic credit supply function (equation [12] with the chosen functions for F and G). We can identify the adjustment cost parameter (α), the elasticity of demand parameter (ϵ) and the parameter b when G has a linear form; thus, the estimated expression is:

$$\frac{1}{(1-\tau)[r_t + 2b(B_{it}/P^I_{jt}K_{it})]+1}\frac{P_{jt+1}}{P_{jt}}\left[\frac{CF_{it+1}}{K_{it}} - 1/\epsilon\frac{Y_{it+1}}{K_{it}} + \frac{\alpha}{2}(1-1/\epsilon)\left(\frac{I_{it+1}}{K_{it}}\right)^2\right] + \alpha(1-1/\epsilon)(1-\delta_j)\frac{I_{it+1}}{K_{it}} \quad [14]$$

$$+b\left(\frac{B_{it}}{P^I_{jt}K_{it}}\right)^2 + \frac{1}{(1-\tau)[r_t + 2b(B_{it}/P^I_{jt}K_{it})]+1}\frac{P_{jt+1}}{P_{jt}}\left[(1-\delta_j)p^I_{jt+1} - \alpha(1-1/\epsilon)\left(\frac{\delta_j^2}{2}-\delta_j\right)\right] + \alpha(1-1/\epsilon)\delta_j - p^I_{jt} = e_{it+1}.$$

[10] We use the weighting matrix proposed by Newey and West (1987), which guarantees that it is positive definite. We also assume that the e_{it+1} correlation between firms is zero.

In the case the credit supply fraction is quadratic we estimate b_1 and b_2 instead of b:

$$\frac{1}{(1-\tau)[r_t+2b_1\frac{B_{it}}{P^I_{it}K_{it}}+3b_2\left(\frac{B_{it}}{P^I_{it}K_{it}}\right)^2]+1}\frac{P_{jt+1}}{P_{jt}}$$

$$\left[\frac{CF_{it+1}}{K_{it}}-1/\epsilon\frac{Y_{it+1}}{K_{it}}+\frac{\alpha}{2}(1-1/\epsilon)\left(\frac{I_{it+1}}{K_{it}}\right)^2\right.$$

$$\left.+\alpha(1-1/\epsilon)(1-\delta_j)\frac{I_{it+1}}{K_{it}}+b_1\left(\frac{B_{it}}{P^I_{jt}K_{it}}\right)^2+2b_2\left(\frac{B_{it}}{P^I_{jt}K_{it}}\right)^3\right] \quad [15]$$

$$+\frac{1}{(1-\tau)[r_t+2b_1\frac{B_{it}}{P^I_{it}K_{it}}+3b_2\left(\frac{B_{it}}{P^I_{it}K_{it}}\right)^2]+1}$$

$$\frac{P_{jt+1}}{P_{jt}}\left[(1-\delta_j)p^I_{jt+1}-\alpha(1-1/\epsilon)\left(\frac{\delta_j^2}{2}-\delta_j\right)\right]+$$

$$\alpha(1-1/\epsilon)\delta_j-p^I_{jt}=e_{it+1}.$$

In the estimation of the above two equations in first differences we have substituted out the terms with only sectoral variation by sectoral dummies and time dummies. Moreover, as stated in the theoretical section, the estimations of both investment models assume that all the firms have positive dividends, or that the conditional covariance between $\emptyset_{it+1}$ and the variables in $(t+1)$ is constant. The difference between both models is that in [14] or [15] we model explicitly the link between financial and investment decisions, so that we would expect the assumption on the constancy of that correlation to be fulfilled.

4. Results

Table 1 presents the estimation results of the neoclassical investment model with market power (equation [13]) for different sets of instrumental variables. The χ^2 test of the overidentifying restrictions gives the probability of satisfying the orthogonality conditions of the expectation error e_{it+1} with the chosen instruments. We use as instruments lags of all the explanatory variables that appear in the investment equation plus the current levels of the debt and of the liquid assets per unit of capital which, under the neoclassical model, are decided irrespectively of investment. The overidentifying restrictions are rejected both with instruments in $(t-1)$ and in $(t-1)$ and $(t-2)$, if they include real as well as financial variables. On the contrary, when we do not use as instruments the contemporaneous levels of those two variables and the lags of the cash-flow, we accept the model. The three variables are responsible, individually, for the rejection of the model. From the last part of table 1 we may reject the existence of second-order correlation of the estimated residuals[11].

TABLE 1
GMM estimation of an investment function with market power (Equation [10]). Period: 1984-1992

	(t-1) instruments		(t-1) & (t-2) instruments	
	With financial variables	Without financial variables	With financial variables	Without financial variables
Estimated parameters				
α	0.04	0.15	0.05	0.05
(Adjustment cost)	(1.20)	(1.62)	(1.47)	(1.60)
ε	2.97	3.38	3.19	3.39
(Demand elasticity)	(8.21)	(5.35)	(10.22)	(7.33)
Overidentifying Test				
χ^2	22.31	0.53	24.63	9.74
Freedom degrees	5	2	12	6
P-value	0.00	0.77	0.02	0.14
Residual Correlation				
First order	-0.08	-0.13	-0.09	-0.11
Second order	0.07	0.01	0.05	0.03

(t-ratios between brackets)
Instruments in (t-1) the non-financial variables are (I_{t-1}/K_{t-2}), $(I_{t-1}/K_{t-2})^2$, (Y_{t-1}/K_{t-2}), (N_{t-1}/K_{t-2}). The financial variables are $(B/K)_t$, $(AF/K)_t$ and (CF_{t-1}/K_{t-2})
Instruments in (t-1) and (t-2) the above instruments plus the same lagged one period
All estimations include sectoral and temporary dummies as explanatory variables in a linear way They are also included as instruments

The adjustment cost parameter is nearly always significant. Even if we evaluate the adjustment cost function at the average sample values with equals its maximum value 0.1 (and not considering the market power), the adjustment cost function represents only 0.5 % of the investment and 0.1% in terms of output.

[11] Those correlations are obtained from the residuals variance-covariance matrix, averaging within the firms and weighting by the number of available time periods. A maximum value for no first-order correlation at 95% probability is $\pm 2/(\text{observations})^{0.5}$. With a estimated value around -0.11, without financial instruments, we accept the first-order correlation (with 4485 observations). The maximum value for second-order correlation, for MA(1) residuals, at 95% probability, is $\pm 2(1.5/\text{observations})^{0.5}$. Our second-order correlations in table 1, for estimates without financial instruments, are below 0.03 (corresponding to 2977 observations), therefore we reject the existence of second-order correlation.

The parameter indicates that the adjustment cost of the investment function is very low. This value is much lower than that estimated by Whited for the US economy (around 10% of investment). Nevertheless we obtain, as for the US economy, that the estimated parameter is greater with a Q model than with a Euler equation[12]. Within our Euler equation we have two possible interpretations for such a low estimated value of α. One is that we have a measurement error on investment since it has been constructed from capital stock changes. The other is than in our model adjustment costs are already internalized since investment needs one period to be productive because of the time to build technology.

The estimated parameter of demand elasticity, well above one, indicates that firms have on average some market power. When we restrict such a parameter to infinity (competitive case) the estimated value of α does not change but the estimation fit decreases. Another usual assumption is to fix the interest rate, in which case we obtain a rejection of the model.

From table 1 we have concluded that the cause for rejecting the neoclassical investment model for the whole sample is its correlation with financial variables[13]. In table 2 we have the estimated results of the alternative model with two type of credit supply functions of net debt. The valid instruments now include lagged values of real and financial variables.

The overidentifying restrictions are accepted with higher probability if the alternative model considers a quadratic credit supply function instead of a linear function. Nevertheless only with the linear function we obtain a significant elasticity of the credit supply for the whole sample. In this case the estimated value of b (0.005) indicates that, on average, the firms have an additional cost due to their indebtedness of

[12]The first order condition of the optimization problem in section 2 with respect to I_{it} is $q_{it} = p_t^I + (1-\tau)H_{it}^I$, where q_{it} is the shadow price of the capital accumulation constraint. We may relate Tobin's Q or ratio q_{it}/p_t^I with investment given the capital stock and the functional form of H_I The Spanish estimations of the Q model give and adjustment cost between 2% and 6% of investment (see Alonso and Bentolila (1994))

[13]The estimation for firms that distribute dividends in two consecutive periods taking account that this selection may be endogenous, accepts the null hypothesis that the financial variables are not correlated with the error term. That coincides with the results from Alonso (1994)

close to 0.4 percentage points[14]. This additional cost affects investment negatively in two different ways. First, through the debt coefficient term that appears in [14]; and second, through the higher discount rate implied by the same equation.

TABLE 2
GMM estimation of an investment function with market power and elastic credit supply. Period: 1984-1992

	Linear credit supply (equation [14])		Quadratic credit supply (equation [15])	
	(t-1) instruments	(t-1) & (t-2) instruments	(t-1) instruments	(t-1) & (t-2) instruments
Estimated parameters				
α	0.06	0.04	0.07	0.03
(Adjustment cost)	(1.88)	(1.36)	(1 89)	(0.99)
ε	4.49	3.78	4.70	3 21
(Demand elasticity)	(4.04)	(6 07)	(3.75)	(6.69)
b_1	0 002	0.005	0.01	0.02
(credit supply elasticity)	(0 80)	(6.36)	(0.52)	(1 07)
b_2	--	--	-0.00	-0.00
(Credit supply elasticity)			(-0.52)	(-0.74)
Overidentifyng Test				
χ^2	18.73	29.27	12.87	16 18
Degrees of freedom	8	19	11	26
P-value	0 02	0.06	0.30	0 93
Residual Correlation				
First order	-0.14	-0.14	-0 19	-0.16
Second order	-0.11	-0 15	-0.21	-0.12

(t-ratios between brackets)
For the linear credit supply the instruments in (t-1) are (I_{t-1}/K_{t-2}), $(I_{t-1}/K_{t-2})^2$, (Y_{t-1}/K_{t-2}), (N_{t-1}/K_{t-2}), $(B_{t-2}/K)_{t-2}$, (A_{t-2}/K_{t-2}), $(B_{t-2}/K)_{t-2}^2$, (CF_{t-1}/K_{t-2}), $(B_{t-2}I_{t-1}/K_{t-2})$, $(A_{t-2}I_{t-1}/K_{t-2})$. in (t-1) and (t-2) same instruments plus one lag
For the quadratic credit supply the instruments in (t-1) are the same than in the linear case plus $(B_{t-2}/K_{t-2,})^3$, $(A_{t-2}/K_{t-2,})^3$, $(B^2_{t-2}I_{t-1}/K_{t-2})$, $(B^2_{t-2}I_{t-1}/K_{t-2})$

The estimated adjustment cost parameter loss significance and decreases its value with respect to table 1 estimation. That could mean that the adjustment cost function measures not only technological restrictions on new capital but also financial restrictions. The elasticity of demand implies margins $(1/\epsilon)$ around 25%[15], in consonance with those estimated at the Spanish sectoral level by Mazon (1992)[16].

[14] The average sample value of the net indebtedness/capital stock ratio is 0.66
[15] These margins have been calculated on Value Added, if we assume there is a perfect correlation between growth in output and intermediate goods, the mark-up on production would be 7%.
[16] ϵ is identified on the assumption of constant returns to scale. If we drop that assumption, it is not possible to identify separately this new parameter, the demand

As was pointed out in the introduction, the third aim of this paper is to determine whether different groups of firms have differences in the degree of dependence between investment and financial decisions. To do this we categorized the firm according to some variable not correlated with the expectational error in the investment equation, but correlated with the collateral they can offer, their own idiosyncratic risk or associated with their bankruptcy probability risk. Under the null hypothesis that in some of these groups financial and investment decisions are not independent, we expect that the overidentifiying constraints will not be satisfied in the neoclassical investment model and that in the model which adds an elastic credit supply, the elasticity parameters will be significant.

The criterion we used to divide the sample was size, measured by the total employment in the firm[17]. That seems to be a reasonable measure of capital market access, as shown in a large number of papers beginning with Fazzari et al. (1988)[18]. The partition was made taking total employment in the first year for which we have information; we consider as small the firms with a number of workers lower than the median (105 workers) and as large the rest. We hope that using pre-estimation sample information avoids, al least partially, the endogenous selection problem in the sample period, because size (employment) and investment are decided jointly. As can be seen in table A.3, the small firms on average invest more per unit of stock of capital and generate more cash-flow. However, financial restructuring was so strong in smaller firms that in 1992 there was no difference in terms of gross indebtedness between both types of firms and indeed net indebtedness was lower for small firms in 1992.

The estimation results of the model with both credit supply functions is shown in table 3[19]. The linear elasticity model is accepted for small firms only at 99%. Although the parameter b is statistically bigger for small firms, the average debt cost for small firms would be very similar

elasticity parameter (ϵ) and the adjustment cost parameter (α).

[17]The scale variable is employment although in our model such a variable is the stock of capital This is the usual criterion considered when economic policies are taken into account.

[18]For evidence of the Spanish economy see, for example, Estrada et al. (1997).

[19]The estimated neoclassical model, not shown in the table, pass the overidentifying test when financial variables are included as instruments only for large firms. But even for those firms, the p-value of the alternative model is much higher.

than that of large firms[20]. More interestingly, the quadratic credit supply function, although accepted for both type of firms, shows significant values only for the group of small firms. Evermore, both coefficients are positive and significant implying a convex credit supply function. It seems like for that group of firms, because of some of their characteristics correlated with the size, the cost of external funds is more dependent of its actual debt and collateral position. This bigger implicit cost of external resources, even when accepting similar indebtedness levels and associated costs for internal resources at both kinds of firms, will imply a total cost of capital that is higher for small firms than for large ones. For small firms that represent an average premium of 1.9 percentage points above the risk free interest rate. Also, the implied intertemporal discount rate will on average be 0.963 for large firms (using the linear credit function and the average sample values) against 0.949 for small ones (using the quadratic credit function).

TABLE 3

GMM estimation of an investment function for small and large firms

Period: 1984-1992

	Small firms		Large firms	
	Linear credit supply	Quadratic credit supply	Linear credit supply	Quadratic credit supply
Estimated parameters				
α	0.06	0.02	-0.005	-0.01
(Adjustment cost)	(1.58)	(0.52)	(-0.11)	(-0.38)
ε	4.23	4.06	2.32	2.41
(Demand elasticity)	(6.00)	(3.91)	(10.49)	(11.03)
b_1	0.007	0.03	0.006	0.007
(credit supply elasticity)	(2.18)	(2.03)	(6.72)	(1.06)
b_2	--	0.001	--	-0.00
(Credit supply elasticity)		(2.07)		(-0.09)
Overidentifying Test				
χ^2	36.49	28.05	24.02	19.01
Freedom degrees	19	26	19	26
P-value	0.01	0.36	0.20	0.84
Residual Correlation				
First order	-0.07	-0.09	-0.18	-0.21
Second order	0.07	0.05	-0.17	-0.30

(t-ratios between brackets)
Instruments in (t-1) and (t-2): see note in table 2

For both specifications, the differences by size between the other two structural coefficients are also coherent with a priori expectations: the

[20]The sample average of net debt/capital stock is 0.63 for small firms and 0.69 for large firms.

adjustment costs are higher in small firms (although none of them are significant) and the demand for their products is perceived as though there were more competition, i.e. they have less influence on price when they alter the quantity of goods launched on the market[21]. Finally, say that when we used the number of years of the firm as a partition criterion of the sample we also found a higher premium for young firms.

5. Concluding remarks

This paper has tested the significance of financial constraints with a panel of Spanish manufacturing firms in the period 1984-1992. The procedure is to estimate a non linear investment demand function that comes from an optimization problem under uncertainty. Such function takes account of adjustment costs in the investment process and the fact that firms have power in the goods market. It also considers a taxation differential between internal and external funds and one-period lag for the investment to be productive. Moreover, we restrict the cash-flow variable to measure the marginal product capital.

We have first found that the reason for the rejection of the neoclassical investment model is the correlation among its error term and financial variables. This result is similar to the excess sensitivity of linear investment equations to financial variables. The firm´s sample is also characterized by a very low adjustment cost of investment once we take into account the time to build technology and a demand-price elasticity that shows a certain market power.

Second, we have modelled the influence of financial constraints on investment through a credit supply. Investment demand, along with this credit supply, is statistically acceptable and the additional cost in external funds is, averaging the firms, 0.4 percentage points. Those results support the existence of asymmetric information in the credit market, which implies a premium in the cost of the external finance that depends on two characteristics of the firm, indebtedness and collateral.

Third, we have found that small firms are more financially constrained because of the bigger unit cost of their external resources. For that group of firms we accept a convex and increasing credit supply function

[21]The mark-up over production for small firms would be 6%, and for large ones 11%.

with an average premium of 1.9 percentage points above the risk free interest rate. This greater financial cost implies an intertemporal discount rate 1.5% smaller than the remaining firms. This evidence may be more significant given that this sample is characterized by a fall in average indebtedness and which is weightier in the smaller firms, and shows that public policies that try to reduce the financial constrains of certain group of firms should look at the collateral or the bankruptcy risk of those firms.

Appendix

A.1. Sample Selection

The main statistical source is the itemised information about non-financial firms, in the Central de Balances del Banco de España (CBBE), during the period 1983-1992. We select firms that are listed for five consecutive periods or more, discarding those whose main activity was agriculture, energy, construction or services, or which changed activity at some time. Nor did we consider firms whose main owner was at any time the public sector.

Furthermore, we eliminate firms that did not satisfy the following consistency filters: a) null employment; b) did not pay wages; c) gross value added was negative or null; d) the capital stock was negative or null; e) the annual variation rate of capital stock was greater than 3; and f) the annual variation rate of financial assets and liabilities was greater than 50.

The final sample consists of 1,508 firms that cover 12,025 observations (see table A.1).

TABLE A1
Unbalanced panel of firms: 1983-1992

Number of periods	Number of firms	Observations
5	195	975
6	193	1,158
7	226	1,582
8	203	1,624
9	224	2,016
10	467	4,670
Total	1,508	12,025

A.2. Construction of the variables

Individual Variables:

- Gross Value Added: defined as the value of production minus the value of the intermediate inputs. The former includes total net sales and other working incomes, variations in finished and non-finished goods stocks, work for own capital stock and working grants. The value of intermediate inputs is the sum of net purchases, other working expenditures, and taxes linked to production, minus the variation in raw material stocks.

- Employment: the sum of fixed and temporary employment. The latter is the number of temporary workers weighted by the number of weeks worked.

- Cash-Flow: gross value added minus labour costs.

- Gross Investment: defined as the variation in the capital stock book value plus depreciation and other revaluations.

- Capital Stock: the value in replacement terms of the capital stock book value. This magnitude is obtained using a perpetual inventory method (see Salinger and Summers (1983)). This recursive method is based on the following expression:

$$K = [I + (P^I/P^I_{-1}. K_{-1}(1 - \delta)]$$

Where $P^I$is the investment deflator y δ is the economic depreciation of investment goods. As an initial condition we use the capital stock book value.

- Gross Debt: calculated as the sum of the short and long-term book value of the debt with cost.

- Financial Assets: the sum of long and short-term assets plus cash and current accounts.

- Short-Term Financial Assets (or liquid assets): financial assets minus long-term assets.

- Dividends: the proposed dividend distribution per the firm's balance sheet.

Sectoral Variables:

- Gross Value Added Deflators: these are taken from the National Accounts after linking the different year bases.

- Investment Goods Deflator: a weighted average of transport equipment, machinery and tools and industrial building deflators. The weights were taken from the 1986 Spanish input-output tables.

- Economic Depreciation of Investment Goods (δ): a weighted average of the economic depreciation of the former three investment goods taken from Hulten y Wykoff (1981). The weights were also taken from the 1986 Spanish input-output tables .

Aggregate Variables:

- Nominal Interest Rate: the internal rate of return on public debt maturing at over two years.

- Profit tax rate: this is constant and equal to 0.35.

- Investment allowances: the investment deflator is adjusted by an index, equal for all the firms, in which it is assumed that the firms take partial advantage of the legal rate.

TABLE A2
Sample statistics. Period: 1984-1992

	Individual variables			
	Average	Standard Deviation	Minimun	Maximun
Gross value added (Y)	1,138.8	4,096.0	2	91,607
Employment (N)	236.3	705.3	1	15,951
Cash-Flow (CF)	425.6	1,914.9	-17,067	55,114
Gross Investment (I)	152.7	761.5	-10,862	45,391
Capital Stock (K)	1,401.9	4,952.1	1	97,975.8
Gross Debt (B)	756.4	2,727.5	0	71,076
Short-term financial assets (A)	185.7	1,161.6	-257	68,418
Y/K_{-1}	2.096	3.035	0.013	119.593
N/K_{-1}	0.731	1.265	0.009	30.244
CF/K_{-1}	0.645	1.197	-3.890	64.832
I/K_{-1}	0.171	0.266	-0.963	3
Gross debt/K	1.052	1.939	0	51.798
Liquid assets/K	0.391	1.131	-3.730	59.362
B/K	0.661	2.078	-59.362	51.506
	Sectoral variables			
	Average	Standard Deviation	Minimum	Maximum
Inflation (deflator Y)	0.050	0.046	-0.061	0.185
Investment relative price (p^I)	1.024	0.079	0.816	1.285
Economic Depreciation	0.047	0.025	0.019	0.139
Nominal interest rate	0.13	0.014	0.114	0.165

Note: All the individual variables are in real terms and the units are in millions of pesetas except for employment, which is measured in terms of the number of workers.

TABLE A3
Sample statistics by size

	Small: 760 firms, Observations: 6056		Large: 748 firms, Observations: 5969	
	Average	Std. Dev.	Average	Std. Dev.
I/K_{-1}	0.178	0.294	0.163	0.235
CF/K_{-1}	0.699	1.44	0.590	0.884
Gros debt/K	1.093	2.269	1.010	1.532
B/K	0.629	2.491	0.694	1.548

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Resumen

Este artículo analiza, desde una perspectiva empírica, la interrelación entre inversión y variables financieras en un contexto no lineal. El modelo neoclásico de inversión es rechazado debido a su correlación con las variables financieras. Alternativamente, se acepta un modelo de inversión en el que existe una prima sobre el coste de la financiación externa a la propia empresa. Esta prima depende del nivel de su deuda y de la estructura de sus activos. Para las empresas más pequeñas, debido a sus características financieras, se acepta un modelo en el que el coste de los fondos externos es creciente y convexo. Esto implica, para el caso de las empresas manufactureras españolas, una prima media de 1.9 puntos porcentuales sobre el tipo de interés sin riesgo.