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ABSTRACT

This paper analyses the interrelatedness of investment and financial variables with a panel of Spanish manufacturing firms. The neoclassic 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 and we estimate that it represents an average cost of 0.3 percentage points above the market interest rate. We obtain that recently established and small firms, because of their financial characteristics, have a higher premium cost, implying a discount rate between 0.5 and 1 percentage point below that on the remaining firms. Nevertheless, these additional costs are not significant at firms which distribute dividends in consecutive periods.

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.

The first objective of this paper is to test the influence of financial variables on investment decisions within a neoclassical framework for a panel of Spanish manufacturing firms in the period 1984-1992. The second objective is to estimate an alternative investment model and quantify the importance of some of the firms' financial characteristics. The paper argues that the availability of external funds is influenced not only by the firm's current debt position but also by its asset structure. Third, 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.

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 USA. 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 last expansionary period 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 very high increase in investment in the economy (from 17% of GDP in 1984 to 25% in 1990). 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 distribution of assets should be as important as the debt position to obtain the funds that finance investment.

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 maximisation problem and relate it to the "Q" 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 (see Fazzari el al. (1988) for the U.S., Hoshi et al. (1989) for Japan, Devereux and Schiantarelly (1989) for the U.K. and Alonso-Borrego y Bentolila (1994) for Spain). 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 optimisation 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) modelled the shadow price of a restriction on the limit of debt as a function of observable variables. We, however, follow Bond and Meghir (1994) by seting a supply function of funds, known to the firm, that depends on certain characteristics of the firm. In this way we are able to identify and estimate some of the structural parameters. In particular, we show the importance of the debt level and the asset structure together.

We reject a neoclassical model of investment demand, for the sample of Spanish firms, in which investment projects take one period to become productive and interest rates are variable. That is contrary to what Bond and Meghir found for U.K. We also find that the source of that rejection is the correlation of investment disturbances with financial variables. We accept an alternative model for all the sample firms with a elastic credit supply function of the level of external funds and the asset structure. This is also contrary to the Alonso-Borrego (1994) results that accept the Bond and Meghir model for Spanish firms but only for those that pay dividends, finding a significant premium on their external funds. Finally, we also found that this alternative model implies, for presample-chosen small and recently established firms, a lower estimated discount parameter.

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(1) Recently, 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 (for example, working capital). In that context cash-flow still has a significant effect.

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

2. Theoretical fremework

2.1 A neoclasical model of investment

Each firm maximises the discounted present value of real internal resources (π_{it})

$$\text{Max } E_o \sum_{t=1}^{\infty} \left(\prod_{s=0}^{t-1} \beta_{is} \right) \pi_{it} \tag{1}$$

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 ($\pi \geq 0$), 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 and ωN the labour costs. The production function is given by $F(K, N_{-1})$. 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 labour and the cost of investment. Therefore, firm i must satisfy, in each period, the following equality:

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(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.

$$\pi_{it} = (1-\tau) \left[F(K_{it-1}, N_{it}) - \omega_t N_{it} - H(I_{it}, K_{it-1}) - r_{t-1} B_{it-1} \right. \qquad (2)$$

$$\left. + B_{it} - (1 - \Delta p_t^e) B_{it-1} - P_t^I I_{it} \right]$$

where τ is the profit tax, r_{t-1} is the nominal interest rate on the debt and p_t^I is the effective price of the investment goods (corrected by the investment tax allowances [4]. The prices ω_t and p_t^I are deflated by the output price, Δp_t^e being the inflation rate on output between (t-1) and t.

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[5].

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 the internal resources

$$\pi_{it} \geq 0 \qquad (5)$$

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[4] If we break down the real interest rate into nominal interest rate less inflation we can analyse the tax allowances for financial expenditures.

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

Given the stock of capital K_{it-1} and knowing the set of prices, the firm chooses the vector (K_{it}, I_{it}, N_{it}, B_{it}) that maximises (1) given the restrictions (2), (3), (4) and (5).

Once we substitute (3) into (2), the first-order conditions with respect to labour, capital and debt are:

$$N_{it} : \qquad F_N (K_{it-1}, N_{it}) = \omega_t \tag{6}$$

$$K_{it} : \beta_{it} E_t \left[\frac{1+\phi_{it+1}}{1+\phi_{it}} [F_K(K_{it}, N_{it+1}) - H_K(K_{it}, I_{it+1}) + (1-\delta_i) H_I(K_{it}, I_{it+1}) + (1-\delta_i) \frac{1}{(1-\tau)} p^I_{t+1}] \right] - H_I (K_{it-1}, I_{it}) - \frac{1}{(1-\tau)} p^I_t = 0 \tag{7}$$

$$B_{it} : \qquad (1+\phi_{it}) - \beta_{it} \left[(1-\tau) r_t + (1-\Delta p^e_t)\right] E_t (1+\phi_{it+1}) = 0 \tag{8}$$

The first condition shows that the price for the labour 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 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 homogenous of degree one, so that the marginal productivity of capital is $F_K = (F\text{-}NF_N) / K = CF / K$. CF represents the cash-flow or resources generated after the payment of variable inputs.

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.

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

If the restriction of the internal resources (π_{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:

$$\frac{1}{(1-\tau)r_t+(1-\Delta p_t^e)} E_t\left[\frac{CF_{it+1}}{K_{it}} - H_K(K_{it}, I_{it+1}) + (1-\delta_i)\left\{H_I(K_{it}, I_{it+1}) + \frac{1}{(1-\tau)} p_{t+1}^I\right\}\right]$$

$$- H_I(K_{it-1}, I_{it}) - \frac{1}{(1-\tau)} p_t^I = 0 \tag{10}$$

The investment function is non-linear in the change in investment prices and in the level of cash-flow, measuring 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. If we assume that the firm is not a price-taker but faces the known demand $P_t = Y_t^{-1/\epsilon}$ where ϵ is price elasticity, then the marginal productivities and the marginal costs will be premultiplied by the factor $(1 - 1/\epsilon)$. In this case we obtain as an additional term the output per unit of capital which will positively affect the demand for investment:

$$\frac{1}{(1-\tau)r_t +(1 - \Delta p_t^e)} E_t\left[\frac{CF_{it+1}}{K_{it}} - \frac{1}{\epsilon}\frac{Y_{it+1}}{K_{it}} - (1 - \frac{1}{\epsilon}) H_K (K_{it}, I_{it+1})\right.$$

$$\left. + (1 - \delta_i)\left\{(1 - \frac{1}{\epsilon}) H_I (K_{it}, I_{it+1}) + \frac{1}{(1-\tau)} p_{t+1}^I\right\}\right]$$

$$- (1 - \frac{1}{\epsilon}) H_I (K_{it-1}, I_{it}) - \frac{1}{(1-\tau)} p_t^I = 0 \tag{11}$$

Under rational expectations, the expectations terms in (10) or (11) may be substituted out 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 internal resources 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. We analyse the neoclassical and the alternative model in firms that distribute dividends and then that satisfy $\pi_{it+1} > 0$. In that case we would not think that the neoclassical model would be rejected by the data. Finally, we check both models for small and recently established firms which because of their characteristics, could be more financially constrained.

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 asymmetric information 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.

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].

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[6] If $\phi_{it+1}>0$ and its conditional covariance with (t+1) variables is not a constant, the investment equation (10) or (11) 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.

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 mantain a certain level of liquid assets, in 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) and Alonso-Borrego (1994) we set a credit function, known to the firm, elastic to certain characteristics of the firm. We impose that the arguments of such a function are not only the level of debt (B_{it}) but also the level of liquid assets (A_{it}) per unit of capital:

$$r_{it} = r_t + G(B_{it}, A_{it}, K_{it}) = r_t + b\left(\frac{B_{it} - A_{it}}{K_{it}}\right) \qquad (12)$$

Including (12) as a known function in the optimisation problem of the firm we obtain the following investment relationship:

$$\frac{1}{(1-\tau) r_{it} + G_B(B_{it} A_{it}, K_{it}) + (1-\Delta p_t^e)} E_t \Bigg[\frac{CF_{it+1}}{K_{it}} - \frac{1}{\epsilon}\frac{Y_{it+1}}{K_{it}} - (1-\frac{1}{\epsilon}) H_K(K_{it}, I_{it+1})$$

$$- G_K(B_{it}, A_{it}, K_{it}) B_{it} - (1-\delta_i)\left((1-\frac{1}{\epsilon}) H_I(K_{it}, I_{it+1}) - \frac{p_{t+1}^I}{(1-\tau)}\right)\Bigg]$$

$$- (1-\frac{1}{\epsilon}) H_I(K_{it-1}, I_{it}) - \frac{1}{(1-\tau)} p_t^I = 0 \qquad (13)$$

To obtain (13) 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. 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 (12).

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 (13). 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 observes the market interest rate, which we impose as a function of certain decision variables.

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 sectoral 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 either sectoral or aggregate variation. 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 and have been constructed from the Spanish input-output tables.

3.2 Estimation method

The Euler equation (11) of the investment model that assumes its independence from the financial variables, once we incorporate the expectation error, is:

$$\frac{1}{(1-\tau)r_t+(1-\Delta p^e_{jt})}\left[\left(\frac{CF_{it+1}}{K_{it}}\right)-\frac{1}{\epsilon}\left(\frac{Y_{it+1}}{K_{it}}\right)+\frac{\alpha}{2}(1-\frac{1}{\epsilon})\left(\frac{I_{it+1}}{K_{it}}\right)^2\right.$$

$$\left.+\ \alpha\ (1-\frac{1}{\epsilon})\ (1-\delta_j)\left(\frac{I_{it+1}}{K_{it}}\right)\right]-\alpha\ (1-\frac{1}{\epsilon})\left(\frac{I_{it}}{K_{it-1}}\right) \qquad (14)$$

$$+\ \frac{1}{(1-\tau)r_t+(1-\Delta p^e_{jt})}\left[(1-\delta_j)p^I_{jt+1}+\alpha(1-\frac{1}{\epsilon})\left(\frac{\delta^2_j}{2}-\delta_j\right)\right]+\alpha(1-\frac{1}{\epsilon})\delta_j-P^I_{jt}=e_{it+1}$$

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.

The last three terms of (14) only present sectoral and time variation. In order to reduce the uncertainty of the parameter estimations, those terms have been eliminated and approximated to by independent time (a_t) and sectoral (a_j) dummies. 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 investment demand function is not linear in the variables and in the structural parameters. The estimation procedure is the generalised method of moments (GMM, Hansen (1982))[8]. 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 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))[9]. 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 neoclasical investment model and analyse whether that depends on 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 (13) with the chosen functions for F and G is:

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(8) We use a modified version of a GAUSS program written by Hansen, Heaton and Ogaki.

(9) 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.

$$\frac{1}{(1-\tau)\, r_t + b\,\frac{B_{it}}{K_{it}} + (1 - \Delta p^{e}_{jt})} \left[\frac{CF_{it+1}}{K_{it}} - \frac{1}{\epsilon}\frac{Y_{it+1}}{K_{it}} + \frac{\alpha}{2}\,(1 - \frac{1}{\epsilon}) \left(\frac{I_{it+1}}{K_{it}}\right)^2 \right.$$

$$+ \alpha\,(1-\frac{1}{\epsilon})\,(1 - \delta_j) \left(\frac{I_{it+1}}{K_{it}}\right) - \frac{\alpha}{2}\,(1 - \frac{1}{\epsilon})\,\delta_j^2$$

$$\left. + \alpha\,(1 - \frac{1}{\epsilon})\,(1-\delta_j)\,\delta_j + b \left(\frac{B_{it}}{K_{it}}\right)^2 + (1 - \delta_j)\, p^{I}_{jt+1} \right]$$

$$- \alpha\,(1 - \frac{1}{\epsilon}) \left(\frac{I_{it}}{K_{it-1}}\right) + \alpha\,(1 - \frac{1}{\epsilon})\,\delta_j - p^{I}_{jt} = e_{it+1} \qquad (15)$$

By ordering the terms in (15) we can identify the adjustment cost parameter (α), the elasticity of demand parameter (ϵ) and also the parameter b that measures the effect of the firm's net debt level on its financial costs r_{it}.

As stated in the theoretical section, the estimations of both investment models (equations (14) and (15)) assume that all the firms have positive internal resources, or that the conditional covariance between $\varnothing_{it+1}$ and the variables in (t+1) is constant. The difference between the two equations is that in (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.

In fact, there exists a group of firms that generates positive internal resources with certainty in two consecutive periods. If we assume that the internal resources π_{it} that the firm may obtain[10] are not observable, then we can select the firms that satisfy the stronger but observable condition of paying dividends in two consecutive periods ($d_{it+1} > 0$, $d_{it} > 0$). The estimations in this case take into account that the

[10] A tentative explanation may be the large number of firms in the sample that are not quoted and do not pay dividends. We think the remuneration of capital in those firms is not made through dividends.

selection criteria may be endogenous. We follow the estimation procedure of Bond and Meghir and Alonso-Borrego, adding linearly an additional variable that explains the expectation error, the inverse of the Mill ratio associated with the probability that the firms pay dividends in two consecutive periods(11).

4. Results

Table 1 presents the estimation results of the investment model with market power (equation 14) for different sets of instrumental variables. The adjustment cost parameter is nearly always significant but its estimated value is surprisingly low. If we evaluate the adjustment cost function at the average sample values with α equals 0.1 (and not considering the market power), the adjustment cost function represents 0.5 % of the investment and 0.1% in terms of output. This value is much lower than that estimated by Whited for the US economy (around 10% of investment).

The parameter α indicates that the adjustment cost of the investment function is very low. Nevertheless we obtain, as for the US economy, that the estimated parameter α is greater with a Q model than with a Euler equation(12). The Spanish estimations of the Q model give and adjustment cost between 2% and 6% of investment (see Alonso-Borrego and Bentolila (1994)). Within a Euler equation a possible interpretation for such a low estimated value of α is that we have a measurement error on investment since it has been constructed from capital stock changes.

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 ϵ 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.

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(11) See, for example, Heckman (1978).

(12) The first order condition of the optimisation problem in section 2 with respect to the investment good I_{it} is: $q_{it} = p^I_t + (1-\tau)\, H_{Iit}$ when the internal resources constraint is not fulfilled, where q_{it} is the shadow price of the capital accumulation constraint. Tobin's Q or ratio q_{it} / p^I_t is related to investment given the capital stock and the functional form of H_I.

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.

The last part of table 1 shows the first and second-order correlation of the estimated residuals. This is obtained from the residuals variance-covariance matrix, averaging within the firms and weighting by the number of available time periods. Although we have not made a formal test of significance that considers the estimation procedure, a maximum value for no first-order correlation at 95% probability is $\pm 2/(\text{observations})^{0.5}$. Since we obtain values around 0.05, we accept first-order correlation (with 4485 observations) as it corresponds to MA(1) residuals. 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 are below 0.04 (corresponding to 2977 observations), therefore we reject the existence of second-order correlation.

From table 1 we have concluded that the cause for rejecting the noeclassical investment model at the firm level is its correlation with financial variables. In table 2 we have the estimated results of the alternative model with a credit supply function of the debt and the liquid assets. The valid instruments now include lagged values of real and financial variables. The overidentifying restrictions are accepted so that the alternative model is valid, with higher probability in the case of net debt than of gross debt. The estimated value of b (0.004) indicates that, on average, the firms have an additional cost due to their indebtedness of close to 0.3 percentage points[13]. This additional cost affects investment negatively in two different ways. First, through the debt coefficient term that appears in (15); and second, through the lower

[13] The average sample value of the net indebtedness/capital stock ratio is 0.66.

discount rate implied by the same equation. The estimated adjustment cost parameter decreases with respect to the table 1 estimation. That could mean that the adjustment cost function measures not only technological restrictions on new capital but also financial restrictions. Nevertheless, the magnitude of ϵ increases when b is left free. The collinearity of both parameters has no clear interpretation. Such elasticity of demand implies margins ($1/\epsilon$) around 20%, in consonance with those estimated at the Spanish sectoral level by Mazon (1992)[14].

We have estimated the investment function for the firms that distribitute dividends in two consecutive periods, taking into account that this selection may be endogenous[15]. We expect that those firms would not be financially constrained, since they may finance their investment projects by changing the distribution of internal resources.

Table 3 contains the estimations of the probit of paying dividends in two consecutive periods and the investment demand function for those firms. Columns 1 and 2 repeat the exercise of table 2, i.e. we estimate the model under independent investment and financial decisions with financial variables in the first set of instruments but not in the second. The overidentifying test accepts the null hypothesis that the financial variables are not correlated with the error term. These results coincide with those obtained by Martinez and Mato (1993) and Alonso-Borrego (1994), also obtained from a Spanish firms sample. That result is also consistent with an estimated coefficient of b (columns 3 and 4) only significant at 10% probability and much lower than that obtained in table 2. The other two estimated structural parameters take values in consonance with what we were expecting: the adjustment cost (although it is not significant) and the elasticity of demand are smaller than for the whole sample.

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

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[14] 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 elasticity parameter (ϵ) and the adjustment cost parameter (α).

[15] The covariance matrix is not corrected by the possible heteroscedasticity induced by the substitution of the selectivity term and its estimates. We think that since the coefficient of this term is not significant the correction should not be vital.

this we categorised 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, b, the elasticity parameter will not be significant.

The first criterion to divide the sample was size, measured by the total employment in the firm[16]. 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, and as large the rest. We hope that this 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, chart 1 shows that 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. Indeed as can be seen in chart 2, net indebtedness is lower for small firms in 1992.

The estimation results of the neoclassical model and the model with an elastic credit supply is shown in table 4. The first model does not pass the overidentifying test for small and large firms when financial variables are included among the instruments. Thus, the problem of dependence between financial and investment decisions is common to both types of firms, but as columns 3 and, especially, 4 show, it is more significant for small firms. This model is accepted with greater probability and the b parameter is statistically bigger for small firms. Therefore, the small firms would have a debt cost 0.3 percentage points greater than that of large firms[17]. 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

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[16] 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.

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

that is higher for small firms than for large ones. Also, the intertemporal discount rate (β) will on average be 0.965 for large firms against 0.96 for small ones. The other coefficients are also coherent with a priori expectations: the adjustment costs are higher in small firms 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.

The second sample partition criterion was the maturity of the firms. Usually, access to new external financing and its cost are cited as problems that determine whether a new firm is started or not. These difficulties, derived from the risk of the investment process under way, have led to the development of specific financial instruments (for example, venture-capital and participative credits).

Selected as recently established (or youngs) firms those which, in 1983, had not renewed more than once their productive capital (except buildings)[18]. This meant that young firms had been in existence for between 8 and 14 years depending on their industrial sector. As can be seen in the appendix, young firms buy more investment goods in terms of the capital stock, generate more cash-flow, and are more indebted; however their restructuring process, in the sample period, has been faster than at mature firms.

Table 5, which presents the estimation of the two investment rules, only partially confirms that financial difficulties are greater in recently established firms. The neoclassical model for young firms is statistically correct even when the financial variables are included as an instrument, but the residuals show a strong second-order correlation. The alternative investment model behaves better in terms of residual correlation, but the adjustment is greater for mature firms, which are less constrained a priori. The parameter b for young firms is double that of the estimated value for mature firms. In this way, chart 3 shows the estimated indebtedness premium by firms, ordered in terms of their level of net debt. We observe in this chart that the debt premium is higher for young firms than for small firms and that those two groups of firms have a larger premium than the whole sample.

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[18] To determine the number of years needed to review productive capital, the inverse of the sectoral depreciation rates is used. With this selection criterion, the sample changes in relation to that analysed previously due to the fact that the information on the date of establishment of the firm is only available in 1992.

This parameter again reflects the greater cost of external funds and implies an intertemporal discount rate one percentage point lower[19]. However, the results are not satisfactory in the adjustment cost parameter, which is non-significant for young firms. The estimation for demand elasticity, which is greater than for mature firms may be evidence the fact that young firms have lower margins.

5. Concluding remarks

This paper has tested the significance of financial constraints with a panel of manufacturing firms in the period 1984-1992. The procedure is to estimate an investment function solving an optimisation problem under uncertainty. Such function takes account of adjustment costs in the investment process, and of the fact that firms have power in the goods market. It also considers a taxation differential between internal and external funds and a one-period lag for the investment to be productive.

We have first found that the reason for the rejection of the neoclassical investment model, in our panel, is the correlation among its error term and financial variables. The sample is also characterised by a very low adjusment cost of investment (0.5% in terms of investment) 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 whose arguments are the indebtedness level and the liquid assets of the firm. Investment demand, along with this credit supply, is statistically acceptable but the additional cost in external funds is, averaging the firms, only 0.3 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.

We have also found that there are more financially constrained groups of firms such as small and young firms because of the bigger unit cost of their external resources. This greater financial cost implies an intertemporal discount rate between half a point and one point smaller than the remaining firms. Tbis evidence, which is most significant given that this period is characterised by a fall in indebtedness, and which is

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[19] Taking into account that the average net debt/capital stock ratio is 0.87 in recently established firms against 0.49 in mature firms, the difference in the interest rate would be 0.7 percentage points.

weightier in the smaller and younger firms, shows the relevance of collateral and bankruptcy risk in the determination of financial cost. These differences could help explain the cyclical behaviour of investment and other real variables in response to monetary and fiscal shocks (see, for example, Gertler y Gilchrist (1994)).

TABLE 1
GMM ESTIMATION OF INVESTMENT FUNCTION WITH MARKET POWER (EQUATION 14)
PERIOD: 1984 - 1992

	Instruments in (t-1)		Instruments in (t-1) y (t-2)	
	With financial variables	Without financial variables	With financial variables	Without financial variables
Estimates				
α	0.09	0.15	0.12	0.15
(Adjustment coat)	(1.39)	(1.62)	(2.00)	(2.19)
ε	3.63	3.34	3.20	3.28
(Demand elasticity)	(5.92)	(5.34)	(8.38)	(6.11)
Overidentifying Test				
χ^2	29.07	2.24	31.80	11.32
Degrees of Freedom	5	2	10	6
P-value	0.00	0.32	0.00	0.11
Reeidual Correlation				
1^{st} Order	-0.05	-0.06	-0.06	-0.06
2^{nd} Order	0.00	0.00	0.00	0.00

Instru ents 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 $(B/K)_t$, $(AF/K)_t$ y (CF_{t-1}/K_{t-2}).

Instruments in (t-1) and (t-2): the above instruments plus the same instru ents lagged one period.

All estimations include sectoral and temporary dummies aa explanatory variables in a linear way. They are also included as instruments.

TABLE 2
GMM ESTIMATION OF INVESTMENT FUNCTION WITH MARKET POWER AND ELASTIC CREDIT SUPPLY
(EQUATION 15)
PERIOD: 1984 - 1992

	Instruments in (t-1)		Instruments in (t-1) y (t-2)	
	Gross debt	Net debt	Gross debt	Net debt
Estimates				
α	0.08	0.09	0.08	0.06
(Adjustment cost)	(2.37)	(2.23)	(2.62)	(2.26)
ε	10.84	12.41	4.90	5.64
(Demand elasticity)	(0.97)	(0.76)	(3.82)	(3.34)
b	0.009	0.0006	0.004	0.004
(credit supply elasticity)	(1.53)	(1.11)	(1.59)	(3.24)
Overidentifying Test				
χ^2	12.07	9.18	18.00	19.40
Degrees of Freedom	5	6	13	15
P-value	0.03	0.16	0.16	0.20
Residual Correlation				
1^{st} Order	-0.04	-0.08	-0.04	-0.10
2^{nd} Order	-0.08	-0.06	-0.06	-0.06

Instruments in (t-1), with gross debt: (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}), $(B/K)_{t-2}$, $(B/K)^2_{t-2}$, (CF_{t-1}/K_{t-2}), $(A/K)_{t-2}$. Instruments in (t-2) with net debt: adding $(A/K)^2_{t-2}$

Instruments in (t-1) y (t-2): the above instruments plus the same instruments lagged one period.

All estimations include sectoral and temporary dummies as explanatory variables in a linear way. They are also included as instruments.

TABLE 3
GMM ESTIMATION OF INVESTMENT FUNCTION FOR THE DIVIDEND-PAYING FIRMS
PERIOD: 1984-1992

	Investment f. with market power		Investment f. with elastic credit supply	
	With financial variables as instruments	Without financial variables as instruments	Gross debt	Net debt
Estimates				
α (Adjustment cost)	0.23 (1.60)	0.22 (1.63)	0.03 (0.47)	0.05 (0.86)
ε (Demand elasticity)	2.44 (12.11)	2.85 (7.47)	2.45 (12.32)	2.43 (14.76)
b (Credit supply elasticity)	-	-	0.002 (1.80)	0.03 (1,64)
λ (Selectivity correction)	-0.07 (-0.78)	-0.01 (-0.07)	-0.13 (1.23)	-0.05 (0.52)
Overidentifying Test				
χ^2	6.65	1.85	10.77	17.23
Degrees of freedom	9	5	12	14
P-values	0.67	0.87	0.55	0.24
Residual Correlation				
1^{st} order	-0.20	-0.19	-0.15	-0.11
2^{nd} order	-0.00	-0.01	0.01	0.02

Instruments in (t-1) and (t-2): see footnote Table 1 for instruments in the first two columns and Table 2 for the last two.

Probit for paying dividends in two consecutive periods (d_{it+1} and d_{it})
Number of observations: 7501

Right-hand side variables

(d_{it-1}, d_{it-2})	$(I/K_{-1})_{t-1}$	$(I/K_{-1})^2_{t-1}$	$(CF/K_{-1})_{t-1}$	$(Y/K_{-1})_{t-1}$
1.73 (47.14)	-0.008 (0.07)	-0.001 (0.02)	0.20 (5.53)	-0.02 (1.45)
$(B/K)_{t-1}$	$(A/K)_{t-1}$	$(N/K_{-1})_{t-1}$	$(B/K)^2_{t-1}$	$(A/K)^2_{t-1}$
-0.C9 (5.56)	0.08 (2.79)	-0.05 (1.44)	0.002 (3.61)	-0.004 (2.08)

pseudo R^2 = 0,31

TABLE 4
GMM ESTIMATION OF INVESTMENT FUNCTION BY SIZE
PERIOD: 1984-1992

	Small Firms			
	Investment f. with market power		Investment f. with elastic credit supply	
	With financial variables as instruments	Without financial variables as instruments	Gross Debt	Net Debt
Estimates				
α (Adjustment cost)	0.18 (2.46)	0.30 (3.28)	0.13 (3.35)	0.08 (2.36)
ε (Demand elasticity)	3.50 (8.89)	10.39 (2.35)	6.96 (3.00)	6.43 (3.47)
b (Credit supply elasticity)	-	-	0.07 (1.37)	0.01 (2.24)
Overidentifying Test				
χ^2	35.84	2.92	16.11	22.12
Degrees of freedom	10	6	13	15
P-value	0.00	0.81	0.24	0.14
Residual Correlation				
1st order	-0.03	-0.11	-0.08	-0.06
2nd order	0.00	-0.02	-0.02	0.00
	Large Firms			
	Investment f. with market power		Investment f. with elastic credit supply	
	With financial variables as instruments	Without financial variables as instruments	Gross debt	Net debt
Estimates				
α (Adjustment cost)	0.07 (0.97)	0.03 (0.34)	0.05 (1.37)	0.02 (0.51)
ε (Demand elasticity)	2.65 (10.67)	2.27 (4.07)	4.14 (4.01)	4.66 (3.64)
b (Credit supply elasticity)	-	-	0.005 (1.76)	0.005 (4.66)
Overidentifying Test				
χ^2	18.22	7.12	13.61	14.11
Degrees of freedom	10	6	13	15
P-value	0.05	0.31	0.40	0.52
Residual Correlation				
1st order	-0.06	-0.07	-0.04	-0.09
2nd order	0.01	0.02	-0.05	-0.05

Instruments in (t-1) and (t-2): see footnote Table 1 for instruments in the first two columns and Table 2 for instruments in the last two.

TABLE 5
GMM ESTIMATION OF INVESTMENT FUNCTION BY AGE
PERIOD: 1984-1992

	Young Firms			
	Investment f. with market power		Invesment f. with elastic credit supply	
	With financial variables as instruments	Without financial variables as instruments	Gross debt	Net debt
Estimates				
α (Adjustment cost)	-0.10 (-0.38)	0.10 (0.50)	0.02 (0.35)	-0.11 (-1.29)
ε (Demand elasticity)	1.88 (23.34)	2.50 (5.46)	4.01 (3.26)	5.02 (2.25)
b (Credit supply elasticity)	-	-	0.015 (2.51)	0.012 (2.10)
Overidentifying Test				
χ^2	7.17	5.91	17.67	20.43
Degrees of freedom	10	6	13	15
P-Value	0.71	0.43	0.17	0.16
Residual Correlation				
1^{st} order	0.27	-0.10	-0.02	-0.13
2^{nd} order	0.14	-0.03	-0.04	-0.02

	Mature Firms			
	Investment f. with market power		Investment f. with elastic credit supply	
	With financial variables as instruments	Without financial variables as instruments	Gross debt	Net debt
Estimates				
α (Adjustment cost)	0.15 (1.19)	0.18 (1.47)	0.11 (2.60)	0.09 (2.20)
ε (Demand elasticity)	2.27 (14.30)	2.76 (4.43)	5.53 (2.06)	2.60 (7.76)
b (Indebtedness-credit supply elasticity)	-	-	0.009 (1.89)	0.006 (8.86)
Overidentifying Test				
χ^2	19.82	8.63	19.33	21.58
Degrees of freedom	10	6	13	15
P-value	0.03	0.20	0.11	0.12
Residual Correlation				
1^{st} order	-0.20	-0.21	-0.21	-0.30
2^{nd} order	-0.05	-0.05	-0.04	-0.04

Instruments in (t-1) and (t-2): see footnote Table 1 for instruments in the first two columns and Table 2 for instruments in the last two.

CHART 1

Gross Debt–Capital Stock Ratio
Averages by size

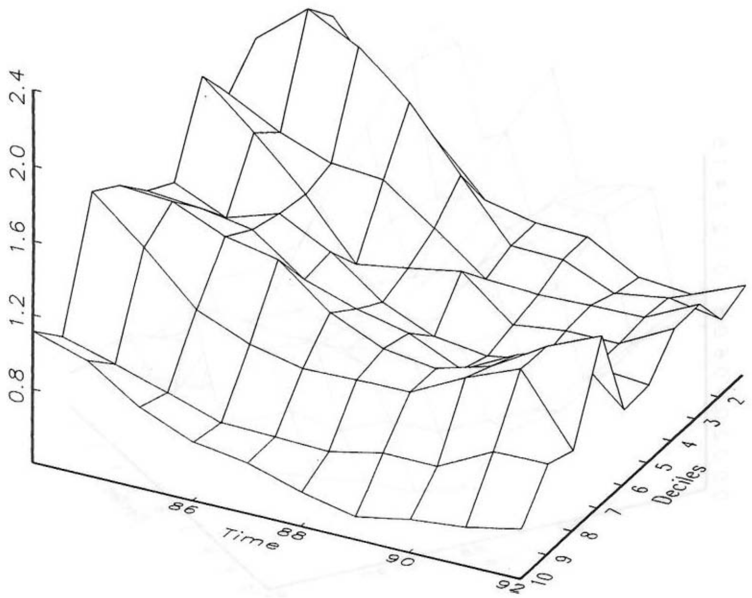


CHART 2

Net Debt–Capital Stock Ratio
Averages by size

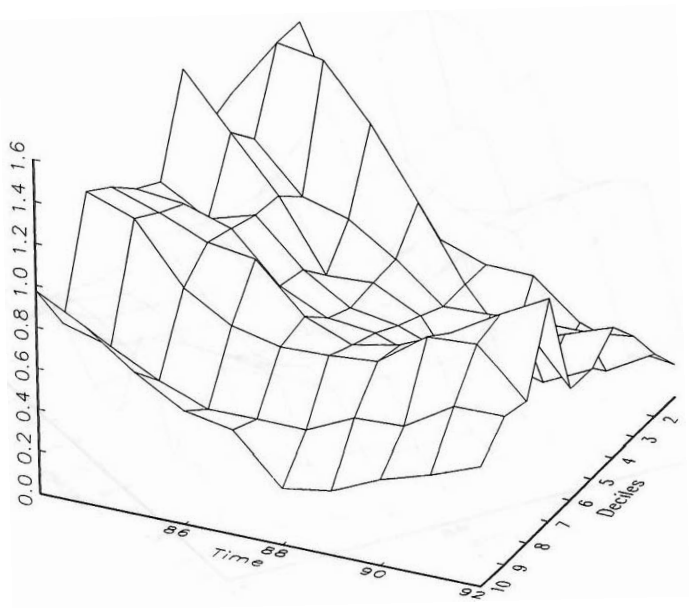
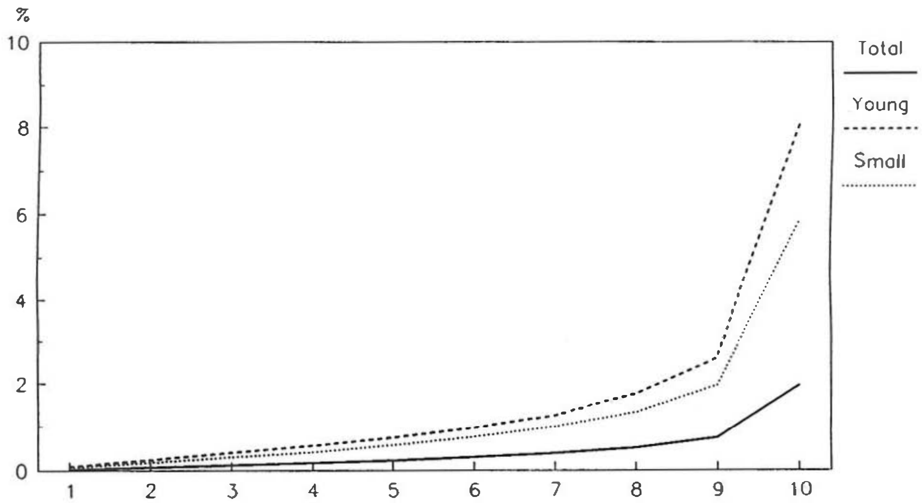


CHART 3

ESTIMATED INDEBTEDNESS PREMIUM
Percentages



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Data 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).

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:

$$K = [I + (P_{INV}/P_{INV-1}) . K_{-1} (1 - \delta)]$$

Where P_{INV} 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 A.1.

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

TABLE A.2
SAMPLE STATISTICS. PERIOD: 1984-1992

	Individual Variables			
	Average	**Standard Deviation**	**Minim m**	**Maximum**
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
Financial assets (AF)	460.4	2,659.5	-257	97,176
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
B/K	1.052	1.939	0	51.798
AF/K	0.511	1.311	-3.730	59.362
A/K	0.391	1.131	-3.730	59.362
(B-AF)/K	0.541	2.147	-59.362	51.506
(B-A)/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 A.3
SAMPLE STATISTICS BY GROUP

	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
B/K	1.093	2.269	1.010	1.532
(B-A)/K	0.629	2.491	0.694	1.548
ΔB/K	-0.037	3.062	0.015	0.943
Δ(B-A)/K	-0.082	3.191	-0.002	0.986

	Recently established 219 firms Observations: 1706		Mature 278 firms Observations: 5377	
	Average	Std Dev.	Average	Std. Dev.
I/K_{-1}	0.229	0.350	0.151	0.224
CF/K_{-1}	0.891	1.370	0.591	0.985
B/K	1.278	2.731	0.900	1.469
(B-A)/K	0.867	2.820	0.492	1.788
ΔB/K	-0.010	3.303	0.025	0.969
Δ(B-A)/K	-0.066	3.313	-0.001	1.081

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