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Ownership Structure and Credit Constraints: A Stochastic Frontier Analysis

Anubha Dhasmana
Assistant Professor of Economics & Social Sciences
Indian Institute of Management Bangalore
Bannerghatta Road, Bangalore – 5600 76
anubha.dhasmana@iimb.ac.in

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Abstract

This paper studies the role of ownership structure in determining the relationship between firm characteristics and credit constraints affecting firm level investment. Firm size is a significant determinant of credit constraints in case of business group un-affiliated firms, domestic firms, and firms with promoters as majority shareholders. Same is not the case for business group affiliated firms, foreign firms, and firms where promoters are not the majority shareholders. Given that the former group of firms are likely to face greater information asymmetry, firm size appears to mitigate the problem of information asymmetry significantly.

Keywords: Investment, Credit Constraints, Ownership Structure

1. Introduction

COVID19 brought back the question of credit constraints and their impact on firm's demand for inputs (Balduzzi et.al, 2020). Following the lessons from 2008-09 financial crisis a lot of policy measures were aimed at providing credit support to businesses in the form of new lending under concessional terms, credit guarantees etc. (Cirera et.al, 2021).

In developing countries like India where firms are more likely to be credit constrained directed credit programmes can spur production and be more effective as countercyclical policy tools (see Banerjee and Duflo, 2014). This paper uses stochastic frontier approach to model financial constraints facing Indian firms with different ownership structure which can be useful guide for directed credit programmes designed to support firms in face of exogenous shocks.

Contributions of this paper are two-fold: first, estimating a Euler equation-based frontier investment demand equation for a panel of Indian firms; second, exploring how ownership structure affects relationship between firm characteristics and credit constraints.

The paper builds on multiple strands of literature. First, Whited (1992) and Campello et. al. (2010) studies the effects of financial constraints on firms' spending decisions. Second, this paper relates to the literature on relationship between firm characteristics and financial frictions (e.g., Audretsch and Elston (2002); Beck and Demirguc-Kunt (2006)). With few exceptions, this literature compares measures of investment-cash flow sensitivity across different sub-samples of firms often split based on arbitrary criterion. Finally, the paper relates to the literature on corporate structure and financial constraints (Hoshi et.al (1991), George et.al. (2010) and Bhaumik et. al. (2012)). This paper is most closely related to the last study by Bhaumik et. al (2012) which uses stochastic frontier analysis to model financial constraints facing Indian firms. However, unlike them, our focus is on the relationship between firm ownership and factors affecting financial constraints.

Rest of the paper is organised as follows. Section 2 presents a model of profit maximizing firm facing imperfect competition and information asymmetry to motivate our empirical approach. Section 3 presents the empirical model and the data used to estimate it. Finally, section 4 presents our results and the discussion.

2. Model

We motivate our empirical work by using a standard model of investment by firm facing convex adjustment costs to derive a set of Euler equations. The owners and managers of the firm are risk neutral. The managers act on behalf of the stockholders to maximize the value of the firm. At time t, all present variables are known to the firm with certainty while all future variables are stochastic. Finally, managers are assumed to be rational[1].

In the absence of any asset bubbles, the value of the firm is simply the present discounted value of the expected after-tax dividend stream. The firm maximizes its market value subject to the capital accumulation equation:

$$K_{i,t} = I_{i,t} + (1-\delta)K_{i,t-1}$$

Here, $K_{i,t}$ is the capital stock of firm i at the end of time t, $I_{i,t}$ is its investment at time t, and δ is the constant rate of depreciation. The firm faces an increasing and convex cost of adjusting its capital stock given by the function - $\varphi\left(I_{i,t}, K_{i,t-1}\right)$.

Apart from the cost of adjusting its capital stock the firm is also faced with information costs resulting from asymmetric information. This adds to the cost of borrowing by the firm[2]. $\Gamma\left(Z_{i,t}\right) \geq 0$ measures the firm's proneness to information and incentive problems which is a function of firm's characteristics $Z_{i,t}$ such as age, size, ownership concentration etc. A firm more likely to suffer from information problems has a larger $\Gamma\left(Z_{i,t}\right)$. For the same level of $B_{i,t}$, $B_{i,t-1}$ and $K_{i,t-1}$, a firm with higher $\Gamma\left(Z_{i,t}\right)$ incurs higher information costs. In the absence of information asymmetry, $\Gamma\left(Z_{i,t}\right) = 0$ and firm incurs no information cost of borrowing. In this case firm would be indifferent between its internal funds versus external sources of funds to finance its investment.

Cash inflows of the firm include sales and net borrowings while the outflows include dividends, interest payments and investment expenditures.

Firm's dividends can therefore be written as:

$$d_{i,t} = \theta_{i,t}K_{i,t-1}^{\alpha} - \varphi\left(I_{i,t}, K_{i,t-1}\right) - I_{i,t} + B_{i,t} - r_t B_{i,t-1} - \frac{\Gamma(Z_{i,t})}{2}\frac{\left(B_{i,t}-B_{i,t-1}\right)^2}{B_{i,t-1}} \qquad (1)$$

Where:

$\theta_{i,t}$ = Idiosyncratic firm level productivity shock
$B_{i,t}$= Net debt outstanding of firm i at time t
r_t = Interest rate on corporate debt
$\frac{\Gamma(Z_{i,t})}{2}\frac{\left(B_{i,t}-B_{i,t-1}\right)^2}{B_{i,t-1}}$ = Cost wedge between internal and external finance which results from information asymmetry[3].

[1] To simplify matters we ignore issuing of new shares by the firm to focus on the effects of restrictions on outside debt.
[2] Cost of borrowing could include underwriting fee, bankruptcy costs etc.
[3] This is like the information cost function in Wang (2003).

Maximization problem of the firm at time 0 can be written as:

$$V_{i,0} = \max_{\{K_{i,t};B_{i,t}\,\forall t\}} E_0 \sum_{t=0}^{\infty} \beta^t \times d_{i,t} \qquad (2)$$

Subject to $K_{i,t} = I_{i,t} + (1-\delta)K_{i,t-1}$

β is the discount factor of the firm. Lagrange for the above problem can be written as:

$$L_{\,i,0} = E_0 \sum_{t=0}^{\infty} \beta^t \left\{\theta_{i,t} K_{i,t-1}^{\alpha} - \varphi\left(I_{i,t}, K_{i,t-1}\right) - I_{i,t} + B_{i,t} - r_t B_{i,t-1} - \frac{\Gamma(Z_{i,t})}{2} \frac{\left(B_{i,t} - B_{i,t-1}\right)^2}{B_{i,t-1}}\right\} + E_0 \sum_{t=0}^{\infty} \beta^t \lambda_{i,t} \left\{(1-\delta)K_{i,t-1} + I_{i,t} - K_{i,t}\right\} \quad (3)$$

First order optimality conditions of the firm are:

i. $\frac{\partial L_{i,t}}{\partial I_{i,t}} = -\beta^t \left\{1 + \frac{\partial \varphi(I_{i,t}, K_{i,t-1})}{\partial I_{i,t}}\right\} + \beta^t \lambda_{i,t} = 0$

ii. $\frac{\partial L_{i,t}}{\partial K_{i,t}} = E_0 \left[-\beta^t \lambda_{i,t} + \beta^{t+1}\left\{\alpha \theta_{i,t+1} K_{i,t}^{\alpha-1} - \frac{\partial \varphi(I_{i,t+1}, K_{i,t})}{\partial K_{i,t}}\right\} + \beta^{t+1} \lambda_{i,t+1}(1-\delta)\right] = 0$

iii. $\frac{\partial L_{i,t}}{\partial B_{i,t}} = \beta^t \left(1 - \Gamma\left(Z_{i,t}\right) \frac{B_{i,t} - B_{i,t-1}}{B_{i,t-1}}\right) + E_0 \beta^{t+1} \left[\left(-r_{t+1} - \Gamma\left(Z_{i,t+1}\right) \frac{B_{i,t+1} - B_{i,t}}{B_{i,t}}\right)\right] = 0$

iv. TVC. :- $\lim_{T\to\infty} \beta^{T-1} B_T = 0$

From equations (i) and (ii) we can write –

$$\beta^t \left(1 + \frac{\partial \varphi\left(I_{i,t}, K_{i,t-1}\right)}{\partial I_{i,t}}\right) = \beta^{t+1} E_0 \left[\alpha \theta_{i,t+1} K_{i,t}^{\alpha-1} - \frac{\partial \varphi(I_{i,t+1}, K_{i,t})}{\partial K_{i,t}} + (1-\delta)\left(1 + \frac{\partial \varphi(I_{i,t+1}, K_{i,t})}{\partial I_{i,t+1}}\right)\right] \qquad (4)$$

Equation (4) simply postulates that along the optimal path, marginal cost of an extra unit of investment in period '*t*' should be equal to the value of an extra unit of capital inside the firm next period. Latter includes the gross marginal physical product of capital along with the effect of an extra unit of capital on the cost of adjusting capital stock and cost of borrowing.

From (iii) we can get:

$$\beta = \frac{\left(1 - \Gamma(Z_{i,t}) \frac{B_{i,t} - B_{i,t-1}}{B_{i,t-1}}\right)}{\left(r_{t+1} + \Gamma(Z_{i,t+1}) \frac{B_{i,t+1} - B_{i,t}}{B_{i,t}}\right)} \approx \left(1 - r_{t+1} - \Gamma\left(Z_{i,t}\right)\left(\frac{B_{i,t} - B_{i,t-1}}{B_{i,t-1}}\right) - \Gamma\left(Z_{i,t+1}\right)\left(\frac{B_{i,t+1} - B_{i,t}}{B_{i,t}}\right)\right)$$

Thus, we can write (4) as:

$$\left(1+\frac{\partial\varphi(I_{i,t},K_{i,t-1})}{\partial I_{i,t}}\right)=$$
$$E_0\left[\left(1-r_{t+1}-\Gamma(Z_{i,t})\left(\frac{B_{i,t}-B_{i,t-1}}{B_{i,t-1}}\right)-\Gamma(Z_{i,t+1})\left(\frac{B_{i,t+1}-B_{i,t}}{B_{i,t}}\right)\right)\left(\alpha\theta_{i,t+1}K_{i,t}^{\alpha-1}-\frac{\partial\varphi(I_{i,t+1},K_{i,t})}{\partial K_{i,t}}+\right.\right.$$
$$\left.\left.(1-\delta)\left(1+\frac{\partial\varphi(I_{i,t+1},K_{i,t})}{\partial I_{i,t+1}}\right)\right)\right] \qquad (4')$$

To proceed further we define the following convex capital adjustment cost function:

$$\varphi(I_{i,t},K_{i,t-1})=\frac{1}{2}\left(\frac{I_{i,t}}{K_{i,t-1}}-c\right)^2 K_{i,t-1} \qquad (5)$$

Equation (4') can therefore be written as:

$$(1-c)+\frac{I_{i,t}}{K_{i,t-1}}$$
$$=E_0\beta\left[\alpha\theta_{i,t+1}K_{i,t}^{\alpha-1}-\left\{c^2-\frac{1}{2}\left(\frac{I_{i,t+1}}{K_{i,t}}\right)^2\right\}+(1-\delta)\left(1-c-\frac{I_{i,t+1}}{K_{i,t}}\right)\right] \qquad (6)$$

Replacing $\theta_{i,t+1}K_{i,t}^{\alpha-1}=\left(\frac{Y_{i,t+1}}{K_{i,t}}\right)$ we get:

$$(1-c)+\frac{I_{i,t}}{K_{i,t-1}}=E_0\beta\left[\alpha\left(\frac{Y_{i,t+1}}{K_{i,t}}\right)-\left\{c^2-\frac{1}{2}\left(\frac{I_{i,t+1}}{K_{i,t}}\right)^2\right\}+(1-\delta)\left(1-c-\frac{I_{i,t+1}}{K_{i,t}}\right)\right] \qquad (6')$$

Define $\Psi_{i,t}=\left(1-r_{t+1}-\Gamma(Z_{i,t})\left(\frac{B_{i,t}-B_{i,t-1}}{B_{i,t-1}}\right)-\Gamma(Z_{i,t+1})\left(\frac{B_{i,t+1}-B_{i,t}}{B_{i,t}}\right)\right)=\beta$ to rewrite (6') as:

$$(1-c)+\frac{I_{i,t}}{K_{i,t-1}}=E_0\Psi_{i,t}\left[\alpha\left(\frac{Y_{i,t+1}}{K_{i,t}}\right)-\left\{c^2-\frac{1}{2}\left(\frac{I_{i,t+1}}{K_{i,t}}\right)^2\right\}+(1-\delta)\left(1-c-\frac{I_{i,t+1}}{K_{i,t}}\right)\right] \qquad (7)$$

Log-linearizing (7) around the steady state gives us the following equation:

$$\ln\frac{I_{i,t}}{K_{i,t-1}}=\left[\gamma_0+\gamma_1\ln\frac{Y_{i,t+1}}{K_{i,t}}+\gamma_2\ln\frac{I_{i,t+1}}{K_{i,t}}+\ln\Psi_{i,t}+\varepsilon_{i,t},\ \varepsilon_{i,t}\sim N(0,\sigma_\varepsilon^2)\right]^4 \qquad (8)$$

[4]See Appendix for details of the derivation

Equation (8) states that rate of investment today is positively correlated with the rate of expected future output and investment along with a set of firm level characteristics that capture financial frictions.

3. Empirical Model

To derive investment demand equation that can be estimated using data we modify equation (8) in several ways. First, we use sales as a proxy for firm's output and use lagged levels of right-hand side variables to capture their current values[5]. Second, we include lagged index of firm level stock return volatility to capture the impact of uncertainty on investment demand under costly adjustment[6]. Finally, we include firm and time specific fixed effects to control for omitted variable bias. This gives us equation (9)

$$\ln\frac{I_{i,t}}{K_{i,t-1}} = \vartheta_0 + \vartheta_1 \ln\frac{S_{i,t-1}}{K_{i,t-2}} + \vartheta_2 \ln\frac{I_{i,t-1}}{K_{i,t-2}} + \vartheta_3\sigma_{i,t-1}^2 + \ln\Psi_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t},$$
$$\varepsilon_{i,t} \sim iid\ N(0, \sigma_\varepsilon^2) \qquad (9)$$

Above investment demand equation uses μ_i to capture firm level characteristics affecting investment frontier and a set of time dummies - λ_t to capture time specific shocks that can affect firm level investment and sales simultaneously.

Equation (9) shows that the rate of growth of investment is a function of lagged sales, investment rate, firm level uncertainty and an unspecified function of financial variables and firm characteristics. In the absence of information asymmetry $\Gamma(Z_{i,t}) = 0$ and the financial friction term in equation (9) becomes $(1 - r_{t+1}) > 0$. In the presence of information asymmetry $\Gamma(Z_{i,t}) > 0$ and the last term in equation (9) becomes $\left(1 - r_{t+1} - \Gamma(Z_{i,t})\left(\frac{B_{i,t} - B_{i,t-1}}{B_{i,t-1}}\right) - \Gamma(Z_{i,t+1})\left(\frac{B_{i,t+1} - B_{i,t}}{B_{i,t}}\right)\right) < (1 - r_{t+1})$. This implies:

$$E\left(\frac{I_{i,t}}{K_{i,t-1}} | \Omega_t; \Gamma(Z_{i,t}), \Gamma(Z_{i,t+1}) = 0\right) - E\left(\frac{I_{i,t}}{K_{i,t-1}} | \Omega_t; \Gamma(Z_{i,t}), \Gamma(Z_{i,t+1}) > 0\right) > 0 \quad (10)$$

Where Ω_t is the information set at time t. In other words, financing constraints resulting from information asymmetry restrict the investment below the neoclassical level. Capital market imperfections force investment to go below but never above the frictionless level.

We can use the above insight to write the investment demand function as a sum of the frontier investment function given by the neo-classical Euler equation (simplified using Taylor's approximation) and a nonnegative financing constraint effect u_t, with the latter

[5] We experiment with different number of lags, but our key results remain unchanged
[6] See Kang, Lee and Ratti (2014) for details about the construction of firm level volatility index.

being a function of a stochastic random error and variables affecting the firm's ability to obtain finance.

Investment demand function can then be written as:

$$\left(\ln \frac{I_{i,t}}{K_{i,t-1}}\right)^{SF} = \vartheta_0 + \vartheta_1 \ln \frac{S_{i,t-1}}{K_{i,t-2}} + \vartheta_2 \ln \frac{I_{i,t-1}}{K_{i,t-2}} + \vartheta_3 \sigma^2_{i,t-1} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (11.1)$$

And

$$\ln \frac{I_{i,t}}{K_{i,t-1}} = \left(\ln \frac{I_{i,t}}{K_{i,t-1}}\right)^{SF} - u_{i,t};\, u_{i,t} \geq 0; \qquad u_{i,t} \sim \varepsilon\left(\varrho\left(Z_{i,t}\right)\right) \quad (11.2).$$

$Z_{i,t}$[7] is the vector of non-stochastic firm-level variables capturing information asymmetry. In the econometric model, $Z_{i,t}$ determines the distribution of $u_{i,t}$ which is assumed to have an exponential distribution with mean $\frac{1}{\varrho(Z_{i,t})}$ and variance $\frac{1}{\varrho(Z_{i,t})^2}$. Equation (11.2) shows that $\frac{\mathrm{I}_{i,t}}{\mathrm{I}^{SF}_{i,t}} = exp(-u_{i,t})$; where $\mathrm{I}_{i,t} = \frac{I_{i,t}}{K_{i,t-1}}$ and $\mathrm{I}^{SF}_{i,t} = \left(\frac{I_{i,t}}{K_{i,t-1}}\right)^{SF}$. Therefore, $\frac{\mathrm{I}_{i,t}}{\mathrm{I}^{SF}_{i,t}}$ can be seen as investment efficiency which is bounded between 0 and 1. Thus, for example, an efficiency score of 0.7 indicates that a firm's investment is at 70 percent of its desired level. Assuming that this short-fall is due to financial constraints, we can use - $\frac{\mathrm{I}_{i,t}}{\mathrm{I}^{SF}_{i,t}}$ as a measure of financial frictions.

Finally, we define $\varrho(Z_{i,t})$ as –

$$\varrho\left(Z_{i,t}\right) = \omega_0 + \omega_1 \ln \frac{Cas \quad Flow_{i,t}}{K_{i,t-1}} + \omega_2 \ln \frac{Debt_{t-1}}{Equity_{t-1}} + \omega_3 DUMSIZE_t + \omega_4 DUMAGE_t \quad (11.3)$$

Firm size is defined as the three-year average of total income and total assets of a company[8]. The size dummy takes a value of one if firm size in above median and zero otherwise. Dummy for firm age takes a value of 1 if the firm was incorporated before 1991 and 0 if it was incorporated after the year 1991.

Equations 11.1, 11.2 and 11.3 define the stochastic frontier model that we estimate using annual balance sheet data for a panel of Indian firms.

4. Results and Discussion

Our dataset includes a set of around 2300 Indian firms covering a period of thirty-four years between 1988 and 2021. Data on these firms are obtained from widely used PROWESS

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[7] In the benchmark specification Z_t includes log of cash-flow as a share of capital and debt to equity ratio along with dummies to capture firm size and age.

[8] See Prowess Data dictionary at https://prowessdx.cmie.com/kommon/bin/sr.php?kall=wdddisplay for details of these variables.

database maintained by the Centre for Monitoring Indian Economy (CMIE). Data on variables such as sales, investment, cash flow etc. can be directly obtained from the dataset. Apart from these, information regarding the ownership characteristics of the firm such as affiliation to a business group, share of promoter's equity, foreign ownership etc. are also obtained from the CMIE. Table 1 provides summary statistics for some of the key variables used in our model.

Table 2 presents results from our benchmark stochastic frontier model. As expected, rate of investment is positively related to lagged sales and investment rate while being negatively correlated with the index of firm level uncertainty. In the final column, we include the industry specific index of dependence on external finance proposed by Rajan and Zingales (1998) (RZ hereafter) in the frontier equation to capture the effects of financial constraints on the optimal level of investment by firms. As expected, greater dependence on external finance is negatively correlated with the rate of investment. The interaction term between dependence on external finance and firm level volatility is, however, insignificant. Rest of the coefficients retain their signs.

Next, we look at the coefficients of the inefficiency equation which we interpret as measuring the level of financial constraints. A negative coefficient in the inefficiency equation implies that the variable helps alleviate financial constraints (i.e., reduce investment inefficiency) and *vice versa*. Once again, as expected, cash flow, age and firm size help reduce the investment inefficiency or alleviate the financial constraints while higher leverage as measured by the debt-to-equity ratio increases investment inefficiency.

Finally, we estimate our investment frontier equation for firms with different ownership structure. We divide firms in to six groups – business group affiliates, non-affiliated firms, foreign firms, Indian firms, firms with high share of equity held by the promoters (defined as 50 percent or more) and firms with low share of promoters' equity (less than 50 percent).

High proportion of shares held by the promoters can help reduce the agency conflicts arising from the separation of management and ownership and thus alleviate financial constraints.

Table 3 presents the result from our sample splitting exercise. While the signs of all the coefficients remain unchanged for most part, their significance varies. A few points are worth noting in these results. First, size significantly alleviates financial constraints in case of business group non-affiliated firms, domestic firms, and firms with low share of equity held by the promoters. Same is not the case for firms affiliated with business groups, foreign firms, and firms with a high share of equity held by the promoters. This likely indicates that business group affiliated firms, foreign firms, and firms with promoters as majority shareholders are subject to less severe information asymmetry problems.

Second, irrespective of ownership structure, investment by domestic firms is negatively affected by firm level volatility. Same is not the case for foreign firms whose investment seems to respond positively to firm level uncertainty (though the coefficient is statistically insignificant).

Finally, looking at the estimates of average efficiency (last row, Table 3), foreign firms have the highest average level of efficiency (or lowest level of credit constraints) among all the different sub-groups (72 percent) while firms with low share of promoter's equity have the lowest level of efficiency (58 percent). Overall, ownership structure has important implications for financial constraints faced by the firms. Using characteristics such as firm size to design directed credit support programmes can be an effective way for policy makers to allocate scarce financial resources. Choice of ownership structure may, however, be endogenous to the level of financing constraints faced by firms. Exploring such endogeneity can be a fruitful area for future research.

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Table 1: Data Summary

Variable	Observations	Mean	Standard Deviation	
$\ln\left(\frac{I_{i,t}}{K_{i,t-1}}\right)$	93,905	-2.7	1.84	
$\ln\left(\frac{Sales_{i,t}}{K_{i,t-1}}\right)$	129,450	0.73	1.43	
$\Delta\ln\left(\frac{I_{i,t}}{K_{i,t-1}}\right)$	64,446	-0.18	1.87	
$\Delta\ln\left(\frac{Sales_{i,t}}{K_{i,t-1}}\right)$	109,414	-0.06	0.66	
$\ln(Assets_t)$	161,720	5.2	2.14	
$\ln\left(\frac{Cash\ Flow_{i,t}}{K_{i,t-1}}\right)$	117,873	-1.35	1.20	
Debt to Equity ratio	147,257	6.0	146.3	
Firm level volatility	96,914	0.71	0.56	

Table 2: Benchmark Model

Frontier Equation Dependent Variable: $\ln\left(\frac{I_{i,t}}{K_{i,t-1}}\right)$	(1)	(2)	(3)	(4)	(5)
$\ln\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right)$	0.07*** (10.7)	0.08*** (11)	0.018** (2.5)	0.02*** (2.7)	0.024*** (3.0)
$\ln\left(\frac{Sales_{i,t-1}}{K_{i,t-2}}\right)$	0.52*** (27.8)	0.52*** (28)	0.52*** (27.7)	0.52*** (27.7)	0.53*** (26.2)
$\sigma^2_{i,t-1}$	-0.05* (-1.65)	-0.05* (-1.8)	-0.078*** (-2.6)	-0.08*** (-2.6)	-0.13*** (-2.9)
External Finance Dependence (RZ)					-1.35** (-2.3)
External Finance Dependence (RZ)× $\sigma^2_{i,t-1}$					0.06 (0.8)
Inefficiency Equation					
$\ln\left(\frac{Cash\ Flow_{i,t}}{K_{i,t-1}}\right)$	-0.95*** (-26.4)	-0.94*** (-26.5)	-0.84*** (-23.6)	-0.83*** (-23.9)	-0.88*** (-22.2)
$\ln\left(\frac{Debt_{t-1}}{Equity_{t-1}}\right)$	0.003** (2.3)	0.003** (2.3)	0.003** (2.4)	0.003** (2.3)	0.003** (2.0)
$DUMSIZE_t$	-0.28** (-2.2)	-0.36*** (-2.8)	-0.24** (-2.0)	-0.33*** (-2.7)	-0.43*** (-2.9)
$DUMAGE_t$		-0.51*** (-6.4)		-0.52*** (-6.8)	-0.62*** (-6.9)
$Constant$	-2.3*** (-25.1)	-1.9*** (-18)	-2.1*** (-23)	-1.7*** (-16.7)	-1.8*** (-15.6)
Year Dummies	No	No	Yes	Yes	Yes
No. of Observations	19488	19488	19488	19488	15586
No. of Groups	2290	2290	2290	2290	1811
Wald Statistics (p-val.)	0.00	0.00	0.00	0.00	0.00
L.R. Test[9]	19970***	20010***	20397.8***	20437.8***	15927.8***
$E\left[e^{-(u\|\varepsilon)}\right]$	0.62	0.62	0.61	0.61	0.63

[9] The LR test statistic is given by *-2*(LR(H₀)-LR(H₁))*. *LR(H₀)* is the log-likelihood for the restricted model given by the frontier investment Euler equation while *LR(H₁)* is the log-likelihood of the unrestricted stochastic frontier model incorporating the inefficiency constraint. See Kodde and Palm 1986 for the critical values of this test.

Table 3: Ownership Structure and Credit Constraints

Frontier Equation Dependent Variable: $\ln\left(\frac{I_{i,t}}{K_{i,t-1}}\right)$	(1) (Non-affiliated firms)	(2) (Business group affiliates)	(3) (Foreign Firms)	(4) (Domestic Firms)	(5) Promoters' share in total equity - High	(6) Promoters' share in total equity – Low
$\ln\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right)$	-0.01 (-0.8)	0.04*** (4.2)	0.09*** (2.9)	0.016** (2.1)	0.03*** (3.2)	0.02* (1.9)
$\ln\left(\frac{Sales_{i,t-1}}{K_{i,t-2}}\right)$	0.56*** (21.6)	0.45*** (16.9)	0.49*** (6.2)	0.52*** (26.8)	0.50*** (20.8)	0.56*** (18.7)
Firm Level Volatility: $\sigma^2_{i,t-1}$	-0.02 (-0.5)	-0.16*** (-3.9)	0.03 (0.5)	-0.11*** (-3.2)	-0.09** (-2.4)	-0.06 (-1.3)
Inefficiency Equation						
$\ln\left(\frac{Cash\ Flow_{i,t}}{K_{i,t-1}}\right)$	-0.79*** (-14.7)	-0.93*** (-18.7)	-1.1*** (-5.0)	-0.83*** (-22.9)	-0.95*** (-18.1)	-0.74*** (-15.5)
$\ln\frac{Debt_{t-1}}{Equity_{t-1}}$	0.002 (0.8)	0.004** (2.4)	0.01* (1.7)	0.003** (2.2)	0.005** (2.3)	0.00 (0.0)
$DUMSIZE_t$	-0.51*** (-3.1)	-0.28 (-0.9)	-0.37 (-0.4)	-0.35*** (-2.8)	-0.32 (-1.4)	-0.61*** (-3.6)
$DUMAGE_t$	-0.60*** (-5.5)	-0.17 (-1.2)	-1.1* (-1.9)	-0.50*** (-6.3)	-0.31*** (-2.6)	-0.76*** (-7.0)
$Constant$	-1.6*** (-10.8)	-2.2*** (-12.4)	-2.0** (-2.4)	-1.7*** (-16.3)	-2.3*** (-14.3)	-1.1 (-8.6)
Year Dummies	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	9569	9919	1145	18343	11624	7432
No. of Groups	1269	1021	117	2173	1287	847
Wald Statistics (p-val.)	0.00	0.00	0.00	0.00	0.00	0.00
L.R. Test	20251***	9525.8***	837***	19520.6***	9970***	8012***
$E\left[e^{-(u\|\varepsilon)}\right]$	0.61	0.63	0.72	0.61	0.65	0.58

Appendix Log-Linearize Euler equation

$$(1-c)+\frac{I_{i,t}}{K_{i,t-1}}= E_0\Psi_{i,t}\left[\alpha\left(\frac{Y_{i,t+1}}{K_{i,t}}\right)-\left\{c^2-\frac{1}{2}\left(\frac{I_{i,t+1}}{K_{i,t}}\right)^2\right\}+(1-\delta)\left(1-c-\frac{I_{i,t+1}}{K_{i,t}}\right)\right] \qquad (7)$$

RHS: $\frac{I_{i,t}}{K_{i,t-1}} \approx \ln\frac{\bar{I}}{K}+\frac{1}{\left(\frac{\bar{I}}{K}\right)}\left(\frac{\bar{I}}{K}\right)\left[\ln\frac{I_{i,t}}{K_{i,t-1}}-\ln\frac{\bar{I}}{K}\right]=\ln\frac{I_{i,t}}{K_{i,t-1}}$ (i)

LHS: $\Psi_{i,t}\left[\alpha\left(\frac{Y_{i,t+1}}{K_{i,t}}\right)-\left\{c^2-\frac{1}{2}\left(\frac{I_{i,t+1}}{K_{i,t}}\right)^2\right\}+(1-\delta)\left(1-c-\frac{I_{i,t+1}}{K_{i,t}}\right)\right]\approx \ln\Xi+\gamma_1\ln\frac{Y_{i,t+1}}{K_{i,t}}+\gamma_2\ln\frac{I_{i,t+1}}{K_{i,t}}+\ln\Psi_{i,t}+\Theta$ (ii)

Where –

$$\Xi=\left[\alpha\left(\frac{\bar{Y}}{K}\right)-\left\{c^2-\frac{1}{2}\left(\frac{\bar{I}}{K}\right)^2\right\}+(1-\delta)\left(1-c-\frac{\bar{I}}{K}\right)\right]$$

$$\gamma_1=\alpha\left(\frac{\bar{Y}}{K}\right)\left(\frac{1}{\Xi}\right)$$

$$\gamma_2=\left(\frac{\bar{I}}{K}\right)\left(\left(\frac{\bar{I}}{K}\right)-(1-\delta)\right)\left(\frac{1}{\Xi}\right)$$

And $\Theta=-\left[\alpha\left(\frac{\bar{Y}}{K}\right)\ln\frac{\bar{Y}}{K}+\left(\frac{\bar{I}}{K}\right)^2\ln\frac{\bar{I}}{K}-(1-\delta)\left(\frac{\bar{I}}{K}\right)\ln\frac{\bar{I}}{K}\right]\left(\frac{1}{\Xi}\right)$

If we define $\gamma_0=\ln\Xi+\Theta-(1-c)$, then we can write equation (7) after log-linearization as:

$$\ln\frac{I_{i,t}}{K_{i,t-1}}=\left[\gamma_0+\gamma_1\ln\frac{Y_{i,t+1}}{K_{i,t}}+\gamma_2\ln\frac{I_{i,t+1}}{K_{i,t}}+\ln\Psi_{i,t}+\varepsilon_{i,t},\ \varepsilon_{i,t}\sim N(0,\sigma_\varepsilon^2)\right] \qquad (8)$$