Costly Information, Finance and Firm Investment: New Directions of Research of Empirical Methodology

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Abstract

It is well established in the macro-finance literature that finance is a crucial factor in the growth process via capital formation, hence the importance of finance constraint in the theory of investment. A very large empirical literature has emerged to test the hypothesis of finance constrained investment since the publication of the seminal paper of Fazzari, Hubbard and Petersen in 1988. The present paper is a survey of the literature and provides new research methodology to fill the lacunae in the existing literature. Finance constraint is modelled as a one sided deviation from the unconstrained investment frontier as in Stochastic Frontier Analysis. The advantage is that the method does not classify sample firms into groups of differential cost of information *a priori;* the classification is endogenous. Once the efficient frontier is estimated it can be used to identify the nature of finance constraint for each individual firm in every year.

Key words: Credit market imperfection, Asymmetric information, Stochastic Frontier Analysis, Endogenous sample selection.

1. Introduction

Economic theory predicts high informational cost in an imperfect capital market because of the presence of asymmetric information between borrowers and lenders. The resultant adverse selection and moral hazard problems affect the efficient operation of the financial market. Consequently firms have to incur higher cost of finance and often a situation may arise where firm investment is constrained by the availability of finance. After the financial crisis of 2007 hit the globe the importance of finance constraint has become even more important, because of bank failures, restructuring, new prudential regulations etc. have lead to general non-availability of finance. This has its negative impact on investment, growth and profitability and finally on the stock market. In this backdrop the issue of empirical research on the availability of finance and firm level investment deserves its importance.

The empirical literature on firm investment in imperfect capital market is huge and the issue has never died down. Fazzari, Hubbard and Petersen (1988) is the first paper in this area. Later important works include Bond and Meghir (1992), Denis and Sibilkov (2010), Hoshi et al (1991) etc. A very good survey can be found in Hubbard (1998) and more recent references are also available in Kumbhakar et al (2012). With this short introduction the paper next considers alternative approaches in modelling empirical equations and major results in Section 2 and finally Section 3 concludes.

2. Econometric Models – Alternative Approaches

The econometric specification of the investment function is derived from firms' value maximization problem. There are two principal approaches in the empirical literature to tackle the problem of finance constraint. The most popular and widely used is the reduced form regression. It employs Tobin's Q, defined as the stock market valuation of firms vis-à-vis its replacement cost (capital stock at historical prices adjusted for inflation and depreciation). The other approach is structural model estimation, using the Euler equation.

The investment decision of a typical firm is defined as the solution to the dynamic optimization problem:

$$\underset{I_{is}}{\text{Max}}\ E_t \left\{ \sum_{s=t}^{\alpha} \beta_i^s \left[\Pi(K_{is}, \theta_{is}) - C(I_{is}, K_{is}, \lambda_{is}) - p_s\ I_{is} \right] \right\}$$

subject to the capital accumulation constraint $K_{it}=(1-\delta)K_{i,t-1} + I_{it}$, where β_i = subjective discount factor, $\Pi(\cdot)$ = profit function net of taxes, θ_{it}= exogenous shock to the profit function, $C(\cdot)$ = adjustment cost function, p_s= tax adjusted relative price of capital goods, λ_{it}= exogenous shock to C, δ = depreciation rate.

The first order condition gives

$$p_t + C_I(\cdot) = q_{it} \tag{1}$$

where $q_{it} = E_t \left\{ \sum_{s=t}^{\infty} \beta_i^s (1-\delta)[\Pi_K - C_K] \right\}$

The right hand side (1) is just the marginal Q which is a sufficient statistic in the absence of capital market imperfection (Hayashi, 1982).

Specifying a linear homogeneous C function yields an investment specification[1]

$$(I_{it} / K_{i,t-1}) = a_i + b\ [q_{it} - p_t] + \varepsilon_{it} \tag{2}$$

where b is a parameter of the C function and $\in_{it}$ is an optimization error. Under certain assumptions (perfect competition in product and factor markets, homogeneity of fixed capital, linear homogeneity of production and adjustment cost functions, independence of financing and investment decisions) average Q, defined as the stock market valuation of firms vis-à-vis its replacement cost, coincides with marginal Q. Then the estimable equation becomes

$$(I_{it}/K_{i,t-1}) = a_i + b\ Q_{it} + \theta_t + \varepsilon_{it} \tag{3}$$

where Q_{it} is the tax adjusted value of Tobin's Q. In more recent studies other variables are also included, such as sales (to capture demand effect) etc. and these variables are generally denoted by vector X_{it}. This is a panel data estimation and α_i stands for the firm specific effect for the $i^{th.}$ firm and θ_t year dummy.

This form of the investment function holds when there is no friction in the capital market. In the presence of frictions – asymmetric information between lenders and borrowers net worth[2] becomes very important determinant of loan supply to the firm, because net worth determines the collateral strength of the firm. However, there are measurement problems associated with net worth, hence the empirical literature employs cash flow (CF) as the proxy for the change in net worth. Fazzari, Hubbard and Petersen (1988) in their seminal paper proposed the following equation for estimating investment equation of firms likely to face finance constraint

$$(I_{it}/K_{i,t-1}) = a_i + b\ Q_{it} + c\,(CF_{it} / K_{i,t-1}) + \theta_t + \varepsilon_{it} \tag{4}$$

This form of estimating investment is generally followed in the **Reduced form approach**. Later researchers have included balance sheet and other variables, such as market value of debt to total assets, leverage ratio, coverage ratio etc. to capture the impact of financial market imperfections generally denoted by the vector Z_{it}. The sample firms are classified into groups of high and low cost of information on the basis of some criterion in the off-sample year(s). Fazzari, Hubbard and Petersen (1988) used dividend pay-out ratio as the criterion. The justification stems from the fact that for a firm, if finance constrained then

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[1] $C(I_{it}, K_{it}) = \frac{\alpha}{2}\left(I_{it} / K_{it} - a_i - \lambda_{it}\right)^2 K_{it}$.

[2] Other variables such as size, age, credit rating, leverage ratio, main bank system as in Germany or Japan, business group affiliation are some important factors to capture

paying high dividends is not consistent with value maximization. Later researchers have used age, size, credit rating etc. Firms in the high cost group are likely to face a finance constraint and vice versa. A positive significant c for high cost firms in the light of the above discussion implies the rejection of the null hypothesis of no finance constraint.

However, a positive c may result from a number of reasons. For example, a positive demand shock leads to a higher cash flow and consequently higher investment if the demand shock is expected to be permanent (see Kaplan and Zingales, 1997). Fazzari and Petersen (1993) aimed to address this line of criticism and runs as follows. The adjustment cost for working capital investment is lower than for fixed capital, so when firms' investment in fixed capital is constrained by the availability of finance firms reduce investment in working capital. So it is suggested employing the following simultaneous equation system where (4) is substituted by (4′) and (5) is another equation for investment in working capital.

$$(I_{it}/K_{i,t-1}) = a_i + b\ Q_{it} + c\,(CF_{it}/K_{i,t-1}) + d(\Delta(\Delta_{it}/K_{i,t-1}) + \theta_t + \varepsilon_{it} \qquad (4')$$

$$(\Delta WK_{it}/K_{i,t-1}) = e_i + f\,Q_{it} + g\,(CF_{it}/K_{i,t-1}) + h(WK_{it}/K_{i,t-1}) + \theta_t + \xi_{it} \qquad (5)$$

where ΔWK_{it} = investment in working capital. The firms are classified into groups of differential information cost and estimated using panel data method. A positive (and significant) c together with a negative d implies the presence of finance constraint while a positive d implies increased investment in working capital from a positive demand shock. Bagchi et al (2002) for Indian firms and Ding et al (2013) for Chinese firms are some examples in this category.[3]

The reduced form regression though very popular in the literature suffers from the fact that equation (4) or (4′) and (5) are employed on the basis of ad hoc reasoning, not derived from well specified objective function. Whited (1992) is the first attempt to derive the investment equation from firms' value maximization problem with an explicit constraint on the availability of loans and hence called **Structural Equation Approach**. The objective function is specified as a discounted sum of future dividends which is maximized by choice of investment (or capital stock with appropriate substitution) subject to a non-negativity constraint on the dividends:

$$d_{it} \geq 0 \qquad (6)$$

This has the same effect as restriction on new share issues, because small increments in outside equity finance also have the same effect on the current stockholders. This is needed for the borrowing constraint to be effective.[4] The borrowing constraint is introduced in the model by (7) below where the constraint is exogenously given.

$$B_{it} \leq B^*_{it} \qquad (7)$$

The maximization of the value function subject to capital accumulation constraint, (6) and (7) gives two equations. One is the usual first order condition which is some variation of (1) and the combined effects of the two constraints (8) as in below:

$$(1+\phi_{it}) - \beta_i((1+r_t) - \eta^e_t)E_t(1+\phi_{i,t+1}) - \gamma_{it} = 0 \qquad (8)$$

where ϕ_{it} = Lagrange multiplier for (6), r_t = nominal interest rate on loans net of taxes, η^e_t = expected rate of inflation and γ_{it} = Lagrange multiplier for (7). When borrowing constraint does not bind γ_{it} =0. Substituting for ϕ_{it} from (8) in (1) one gets the expression for the investment equation to be estimated.

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[3] It may be of interest to know that Bagchi et al (2002) classified firms by dividend pay-out ratio and found that the group firms with medium dividend pay-out ratio is in fact finance constrained while one would expect low dividend paying firms to be finance constrained.

[4] Whited (1992) argues on the basis of empirical facts that firms are dependent on borrowing than new share issue for raising finance.

$f(X_{it}, \Phi_{it}) + \theta_t + \varepsilon_{it} = 0$, where $\Phi_{it} = 1 - (1+\phi_{i,t+1})/(1+\phi_{it})$, which takes the value zero in the absence of finance constraint. It may be noted that ϕ_{it} is also a function of γ_{it} when borrowing constraint binds. For econometric estimation, however there is another problem, viz. that neither of the Lagrange multipliers is observable. So Φ_{it} (and so γ_{it}) is parameterized as function of observed variables that can capture the degree of finance constraint: $\Phi_{it} = \Phi(Z_{it})$. Statistical significance of these variables provides the test of finance constraint. The sample firms are classified into groups of differential cost of information and estimated using dynamic panel method.[5]

All the above methods suffer from the common problem of classification of firms into differential information cost groups on the basis of off sample observations. However, there is no reason why such a classification will remain same over the years. There is another problem, viz. classification criteria based on different variables will in general give different groupings. However, some or all of these variables

To circumvent this problem Hu and Schiantarelli (1998) proposed **Switching Regression Approach** that takes care of endogenous sample selection. The investment equation is separately specified for high information cost and low information cost groups (in Hu and Schiantarelli terminology high premium and low premium respectively) as given below.

$$(I_{it}/K_{i,t-1}) = a_{1i} + X_{it}\beta^L + \theta_t + \varepsilon_{it} \qquad (9)$$

if $Z_{it}\gamma + u_{it} < 0$

and $$(I_{it}/K_{i,t-1}) = a_{2i} + X_{it}\beta^H + \theta_t + \zeta_{it} \qquad (10)$$

if $Z_{it}\gamma + u_{it} > 0$.

Two inequalities corresponding to (9) and (10) are called switching functions and used to endogenously selects the $i^{th.}$ firm in $t^{th.}$ year to high or low cost regime. Assuming that the vector of error terms $(\varepsilon_{it}, \xi_{it}, u_{it}) \sim N(O,\Sigma)$ one can derive the likelihood function:

$$l_{it} = \varphi(\varepsilon_{it} \mid u_{it} < -Z_{it}\gamma)\Phi[-Z_{it}\gamma] + \varphi(\zeta_{it} \mid u_{it} \geq -Z_{it}\gamma)[1-\Phi(-Z_{it}\gamma)$$

$$= \phi(\varepsilon_{it}, \sigma_\varepsilon)\Phi[(-Z_{it}\gamma - \sigma_{\varepsilon it}/\sigma_\varepsilon^2)/(1-\sigma_{\varepsilon u}^2/\sigma_\varepsilon^2)]$$

$$+ \varphi(\zeta_{it}, \sigma_\zeta)[1-\Phi[(-Z_{it}\gamma - \sigma_{\zeta it}/\sigma_\zeta^2)/(1-\sigma_{\zeta u}^2/\sigma_\zeta^2)]$$

where $\sigma_j^2 = \mathrm{var}(j)$, $\sigma_{jk} = \mathrm{cov}(j,k)$, $j,k = \varepsilon,\zeta,u$.

The log-likelihood function defined as $L = \sum_i \sum_t \log(l_{it})$ can be used to estimate $(\beta^L, \beta^H, \gamma)$. The method treats actual observation as the average of two regimes with the probabilities as the weights. This specification is not entirely correct for each observation also takes a value from the other regime even with a very low weight.

In a recent paper Bhaumik, Das and Kumbhakar (2012) draws on **Stochastic Frontier Analysis** (Kumbhakar and Lovell, 2000) for estimating investment function in an imperfect capital market. A technical efficient frontier of the investment function is specified and the actual investment is one sided deviation from the efficient frontier. The deviation is modelled in the spirit of imperfect capital market to capture finance constraint. The advantages of this approach are the following. First, sample split into differential information cost group is endogenous. Second, a technical efficiency score for each firm in each period can be calculated which is bounded in [0 1]. This helps find not only the presence of finance constraint but also the degree of severity of the constraint. Finally, it is computationally convenient.[6]

[5] Whited (1992) splits the firms on the basis of Moody's bond rating for the pre-sample period.
[6] Wang (2003) is an earlier contribution along this line.

Absent any informational cost the stochastic frontier is specified as some version of (3)

$$\ln\left(I_{it}/K_{i,t-1}\right)^{SF}=\beta X_{it}+\theta_t+a_i+\varepsilon_{it} \quad (11)$$

Denoting the frontier by superscript SF and the deviation by *u* the relationship between the frontier and actual investment is given below.

$$\left(I_{it}/K_{i,t-1}\right)=\left(I_{it}/K_{i,t-1}\right)^{SF}\exp\left(-u_{it}\right) \;\Rightarrow\; \ln\left(I_{it}/K_{i,t-1}\right)=\ln\left(I_{it}/K_{i,t-1}\right)^{SF}-u_{it}$$

The higher the value of *u* greater is the impact of constraints on investment. If *u* is close to zero for some firms then those firms are not supposedly constrained. Specifically, technical efficiency is the investment efficiency defined as the ratio of actual to the efficient investment (i.e., exp(-*u*) which will be bounded between 0 and 1). The efficiency score is estimated for each observation using the frontier technique. Apart from the ease of interpretation, the technical efficiency score has the advantage of capturing the combined impact of all the constraining variables on the extent of credit constraint.

Next the inefficiency because of finance constraint is modelled in terms of firm characteristics, Z variables. Assuming $u_{it}\sim N\left(0,\sigma_u^2\left(Z_{it}\right)\right),\ u_{it}\geq 0$ where $\sigma_u\left(Z_{it}\right)=\exp\left(\gamma' Z_{it}\right)$ to maintain non-negativity, we have $E\left(u_{it}\right)=\sqrt{2/\pi}\,\sigma\left(Z_{it}\right)=\sqrt{2/\pi}\exp\left(\gamma' Z_{it}\right)$. Thus one can easily find the marginal effect of the *Z* variables on investment inefficiency. Indeed, it can be argued that (variations of) the specification used in the OLS and fixed effects panel approaches are a special case of the stochastic frontier model.

Letting $v_{it}=\varepsilon_{it}-u_{it}$, $E\left(v_{it}\right)\neq 0$ because $u_{it}\neq 0$, which poses a problem in using LS method. The problem can be circumvented in the following way. $v_{it}=\varepsilon_{it}-u_{it}=\varepsilon_{it}-[u_{it}-E\left(u_{it}\right)]-E\left(u_{it}\right)=\varepsilon_{it}^{¿}-E\left(u_{it}\right)$ where $E\left(\varepsilon_{it}^{¿}\right)=0$ by construction. To account for the extra term $-E\left(u_{it}\right)$, we assume $-E\left(u_{it}\right)=\gamma' Z_{it}$. Thus the stochastic formulation of the baseline model:

$$\ln\left(I_{it}/K_{i,t-1}\right)=\beta X_{it}+\theta_t+a_i+\varepsilon_{it}-u_{it} \quad (12)$$

along with

$$-E\left(u_{it}\right)=\gamma' Z_{it} \quad (13)$$

completes the econometric specification. One can justify the use of (3) starting from a frontier model. (12) ensures the assumptions on *u* and *v* so that $-\mathrm{E}\left(u_{it}\right)<0$, and thus one can estimate the extent of credit constraint of a firm in each of the years of analysis.

Bhaumik et al applied the technique for around 600 Indian firms for the period 1996-97 to 2005-06. The paper includes (log of) sales and lagged sales along with Q in X_{it} and cash flow, asset, leverage and a dummy for business group affiliation in Z_{it}. The best fit for leverage obtains for a dummy defined if debt-equity ratio exceeds 1.8. The estimate regression equation is given below.

$$\ln\left(I_{it}/K_{i,t-1}\right)^{SF}=-2.5+0.06\ln Q_{it}+0.93\ln\left(SALE_{i,t}/K_{i,t-1}\right)+0.38\ln\left(SALE_{i,t-1}/K_{i,t-2}\right)$$

$$\gamma' Z_{it}=0.58-0.10\left(CF_{it}/K_{i,t-1}\right)-0.07\ \ln\left(ASSET_{it}\right)+0.21\,LEVERAGE_{it}-0.62\ \text{BUNSINESS}\ GROUP_{it}+0.07\left(GROUP_{it}\ \text{x}\ TIME\right)$$

All the coefficients are significant at 1% or 5%. The paper also estimates inefficiency for Z variables in different percentiles. It is found that inefficiency decreases at higher percentiles. Comparison of the distributions of firms between 1996-97 and 2005-06 shows that the distributions of small and large firms (size measured by sales), distributions of high indebted and low indebted firms coincide across the periods, while there is no significant difference in terms of business group affiliation. This clears shows that economic reforms initiated in 1990s have some impact on the Indian capital market.

3. Conclusion

This paper provides a survey of the different strands of empirical methods for estimating firm investment in an imperfect capital market. The paper elucidates the relative merits and demerits of the different methods. The literature has never been dead for two reasons, viz. the issue is very much live and secondly there exists many a lacunae which gives the scope of new studies. The econometric models so far analyzed can also be extended to include the stock price performance of firms with their status in terms of deviation from the optimal investment frontier.The empirical observations of the finance constrained firms are very useful in drawing up monetary and credit policy in an economy.

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