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By: Sumon Bhaumik, Pranab Kumar Das and Subal C. Kumbhakar

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A stochastic frontier approach[*]

Sumon Kumar Bhaumik
Aston Business School, Aston University, UK,
William Davidson Institute, University of Michigan, Ann Arbor, USA and
IZA – Institute for the Study of Labour, Bonn, Germany

Pranab Kumar Das
Centre for Studies in Social Sciences, Calcutta, India

Subal C. Kumbhakar
Binghamton University, USA and
Aston Business School, Aston University, UK

Corresponding author:
Sumon Kumar Bhaumik
Economics and Strategy Group
Aston Business School
Aston University
Aston Triangle
Birmingham B4 7ET
United Kingdom
Email: s.bhaumik@aston.ac.uk
Phone:+44 121 204 3328
Fax: +44 121 204 3000

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Abstract:

We use the stochastic frontier approach to estimate the impact of firm characteristics on investment decisions of Indian firms during the 1997-2006 period. The use of the stochastic frontier approach allows us to define the (unobserved) optimum investment that is consistent with a firm's characteristics such as the Tobin's *q* during each firm-year, and then estimate the deviation from this unobserved optimum in the form of an (investment) efficiency score that varies between zero and one. This deviation is interpreted as the degree of credit constraint, and we are also able to estimate the impact of firm characteristics such as leverage and business group affiliation on the degree of credit constraint via their marginal effects. Our results suggest that the degree of credit constraint of an average firm *increased* over time during the sample period, despite significant reforms of the Indian banking sector by the turn of the century. We also find that the degree of credit constraint decreases with cash flow and assets, which is consistent with the available literature. Further, there is a threshold effect of leverage, and the degree of credit constraint is greater for highly leveraged firms. Finally, we find that the beneficial impact of business group affiliation on the degree of credit constraint decreases over time, and is eliminated by the end of the sample period.

Keywords: Investment, Credit rationing, Imperfect information, Stochastic frontier analysis

JEL classifications: C23, C24, D82, D92, G31, G32

1. Introduction

The relationship between investment and economic growth is well understood. In the context of emerging market economies like India, research has therefore focussed on factors that might inhibit firm-level investment. This has led to discussions about policies aimed at ending financial repression that is associated with government-influenced disbursal of credit and underdeveloped capital markets (Bekaert, Harvey and Lundblad, 2005). A natural extension of this discussion is the debate about the pre-emption of private investment in India by the presence of a large (and presumably less efficient) public sector (Majumdar, 2009).

The literature demonstrates awareness of the fact that in emerging markets financial liberalisation and gradual withdrawal of the public sector from production of goods and services (at least in a relative sense) may not be a panacea for private firms. Research has highlighted the risk aversion of banks which enjoy greater autonomy in the aftermath of financial liberalisation but are also subject to prudential regulation that penalise risky lending. Bhaumik and Piesse (2008) demonstrate that such risk aversion is also evident in the behaviour of public sector banks. Newly autonomous banks, especially those in the public sector, are also hampered by their inability to make judgements about the quality of potential borrowers. Hence, they undertake rule-based lending that awards credit based on sales, rather than on expected profitability or returns on the investment (Banerjee, Cole and Duflo, 2006). Finally, corruption and political intervention might lead to diversion of credit to politically connected firms, presumably at the expense of other (perhaps even more efficient and profitable) firms (Khwaja and Mian, 2006).

However, a literature that analyses the problem of credit constraint (or, more generally, frictions obstructing access to emerging capital/credit markets) on investment from the firms' point of view is still rather small. Most of the existing literature on emerging markets focuses on the impact of financial liberalisation on firm investment: Harris, Schiantarelli and Siregar (1994) for Indonesia; Guncavdi, Bleaney and McKay (1998) for Turkey; Gelos and Werner (2002) for Mexico; Wang (2003) for Taiwan, and Koo and Maeng (2005) for South Korea. In general, the existing research concur that financial liberalisation eases financial constraints of firms. However, this may not be true for all firms. Gelos and Werner (2002) find that financial liberalisation eased credit constraints for smaller Mexican firms but not their larger counterparts. They also find that banks rely on collateral to a significant extent. Wang (2003) too finds that smaller firms in Taiwan benefit more from financial liberalisation than larger firms. Ganesh-Kumar, Sen and Vaidya (2001) focus on overall economic liberalisation instead, and find that firms with more outward orientation, measured by the export intensity of their sales, are less constrained in the financial markets.

In this paper, we examine the nature of credit constraints among manufacturing sector firms from India, for the 1997-2007 period.[1] India has witnessed progressive liberalisation of its real sector since 1985 and its financial sector since 1992. By the second half of the 1990s, the banks enjoyed a fair degree of autonomy (Bhaumik and Piesse, 2008), and the equity market was growing rapidly (Shah and Thomas, 1997). Correspondingly, the post-1991 period witnessed significant growth in both credit and private sector investment.[2] The net outstanding credit to the industrial sector rose from INR 578.6 billion in 1993-94 to INR 3408.9 billion in 2008-09, in real terms, recording an annual average growth rate of 11 percent. However, because of the implementation of stricter prudential norms banks have been holding government securities over and above the prescribed minimum requirement. This has resulted to lower credit growth than what would have been consistent with a higher rate of growth in the real sector (Marjit and Das, 2008). The average annual growth rate of private investment for (roughly) the corresponding period was 17.77 percent. Yet, even during the second half of the last decade, there was *prima facie* evidence of credit constraints inhibiting investment growth at the firm level (Chaudhuri, Koudal and Sheshadri, 2009). The country therefore provides an excellent setting for an empirical examination of the factors that affect firm-level investment in the presence of capital/credit market imperfections and agency conflicts.

We adopt the stochastic frontier approach as a tool to address the above mentioned problem. This approach, which is widely used in the production efficiency literature, is well suited to address our problem in which the outcome variable (desired or optimum investment) has a natural maximum

[1] We do not include data for 2008 and 2007 in our sample to exclude the period of global financial crisis from our sample. While India was not significantly affected by the crisis, there was, nevertheless, a noticeable drop in the country's GDP growth rate, implying a possible change in its business environment.
[2] Resources mobilised through capital market continue to account for less than 3 percent of GDP. By contrast, domestic credit provided by the banking sector rose from 44.1 percent of GDP in 1995 to 64.2 percent of GDP in 2007. By all accounts, India remains a bank based economy.

which is unobserved, such that the observed value of the outcome variable is less than its desired (maximum) value. Thus, the idea is to estimate the unobserved maximum value econometrically using actual data on the outcome variable and some covariates, and thereby compute the shortfall of investment due to credit constraint for every firm and for every year of the period of analysis. This 'shortfall' can be used to define a measure of investment efficiency that is bounded between 0 and 1, so that the frontier is attained when the efficiency is 1. This efficiency score tells us the degree of credit constraint for each firm and for every year. Importantly, this measure reflects the impact of all the factors (observed as well as unobserved) that inhibit attaining the investment frontier, ceteris paribus. Subsequently, we are able to directly estimate the marginal impact of (observed) factors that constrain investment on this efficiency measure. These marginal effects provide a better understanding of the underlying drivers of credit constraints. In particular, policymakers can better understand not only whether policies such as those used for financial sector liberalisation improve efficiency over time, but also whether these policies have differential impact on firms based on characteristics such as size. At the same time, firms themselves develop a better idea about factors that can reduce their credit constraints, thereby giving them a strategic direction.

Our results suggest that, in keeping with the existing literature in firm-level investments, credit constraints are alleviated by cash flows and (log) assets of firms. The degree of credit constraint is higher for highly leveraged firms. The literature suggests that these indicate the presence of adverse selection in the Indian credit market. We also find that business groups alleviate credit constraints for member firms, but their ability to do so has declined over time. However, evidence suggests that while the effectiveness of business group membership itself for alleviating credit constraints was declining over time, business groups were also restructuring in ways that gave them an overall advantage vis-a-vis non-members. Overall, there is a decline in median investment efficiency of the firms over the sample period, when investment efficiency refers to the ability a firm to translate characteristics such as its Tobin's q ratio and sales-to-capital ratio into investment. But, even the marginal impact of business group membership weakens over time, the median investment efficiency of business group members increases relative to non-members over the same period.

The rest of the paper is organised as follows: In Section 2, we briefly review the literature on the determinants of firm-level investment, one that is focussed almost entirely on developed industrialised economies. In Section 3, we draw on the above literature to construct the empirical methodology, emphasising the stochastic frontier approach that distinguishes between drivers of investment in the absence of market imperfections and agency problems, and factors that generate the aforesaid frictions for capital/credit market access. This section also briefly discusses the data. The regression results are discussed in Section 4. Finally, Section 5 concludes.

2. A brief review of the literature

Following the arguments of James Tobin, it is stylised that in a world without capital market imperfections and taxes, the investment of a firm that maximises its net worth will depend on its Tobin's q (Yoshikawa, 1980). The "q" theory posits that if a firm's investment strategies are fundamentally sound then investors' valuation of the firm would be higher than the cost of the assets required to undertake production. Hence, if a firm's q – the ratio of the market value of its assets to the replacement cost of these assets – is greater than 1 then the firm would be encouraged to invest further, while a value of q that is less than 1 would discourage investment.

This basic model about the determinant of investment has been extended in a number of ways. To begin with, recent studies have taken into consideration the possibility that investment decisions may be affected by the demand for a firm's output. In such cases, there is a departure from Hayashi's (1982) argument that under plausible circumstances the marginal q used in Tobin's analysis and the more readily observable average q are identical;[3] investment depends on output as well. Not surprisingly perhaps, early attempts at empirical estimation of investment functions find that, along with (average) q, the output level of firms have statistically significant coefficients (Abel, 1980). This statistically significant relationship is confirmed by more recent studies (Blundell et al., 1992; Cuthbertson and Gasparro, 1995).

[3] Hayashi (1982) demonstrates that for a price taking firm in both the product and factor markets, with a linear homogeneous technology and linear homogeneous adjustment cost of capital, marginal q equals average q.

It was further recognised that since capital markets are prone to failures on account of informational imperfections (Stiglitz and Weiss, 1981), it is important to take into account the factors that determine whether or not a firm is finance constrained. Initially, the literature focussed on the internal resources of the firms, with cash flows as a proxy for internal resources. Fazzari, Hubbard and Petersen (1988) include the firms' cash flows in the specification, and argue that a statistically significant (and positive) coefficient for the cash flow variable indicates the presence of financing constraints.[4] The significance (and positive sign) of the coefficient for the cash flow variable is borne out by a number of empirical studies (e.g., Bond and Meghir, 1994; Devereux and Schiantarelli, 1990; Kadapakkam, Kumar and Riddick, 1998).[5]

It is easy to see that possibility of capital market failure on account of informational imperfections has other implications for a firm's investment. Following Bester (1985) and Besanko and Thakor (1987), it is possible to argue that a firm can overcome financial constraints by posting collateral. An implication of this argument is that smaller firms that have less collateral to post are likely to be more credit constrained than larger firms. This is largely borne out by the available empirical evidence (Audretsch and Elston, 2002; Beck and Demirguc-Kunt, 2006).[6]

The literature also suggests that the impact of capital market failure on investment can be reduced by organisational structures such as business groups. This could be, as in the case of Japan, on account of access to banks that are an integral part of these groups (Hoshi, Kashyap and Scharfstein, 1991). Alternatively, this could be on account of internal capital markets that are generally associated with business groups such as the Korean chaebols (Shin and Park, 1999).

[4] Hubbard (1998) demonstrates that an increase in cash flows, which can be a proxy for an increase in net worth of the firm, leads to an increase in the optimal level of capital, given any cost of capital. Alternatively, it signals a reduction in internal agency problems, especially moral hazard, and hence reduces the (shadow) cost of capital.

[5] It has been argued that a significant coefficient of the cash flow variable does not necessarily indicate presence of a financial constraint. If a firm has the ability to maintain investment in fixed capital by adjusting working capital, the coefficient of the cash flow variable would capture shifts in investment demand. One implication of this line of argument is that reduced form models underestimate the impact of financial constraints on investment (see Fazzari and Petersen, 1993, for details). Some studies have, therefore, used cash holding of firms instead of cash flow (Denis and Siblikov, 2010). However, the use of cash flow in empirical specifications, and the use of its estimated coefficients to draw inferences about financial constraint experienced by firms are stylised in the literature.

[6] Audretsch and Elston (2002) demonstrate that, in Germany, on account of the financial infrastructure to support small firms, it is the medium sized firms that are most credit constrained. But in the United States and the United Kingdom, in keeping with the prediction, the smaller firms are more credit constrained.

Later research takes into consideration the impact of one other source of friction, namely, agency conflict within firms. Following Myers (1977), who notes that debt creates an agency conflict by ensuring that at least a part of the returns from an investment accrues to debt holders rather than share holders, it is argued that managers in highly leveraged firms have less incentive to exploit opportunities for growth and profitable investment. However, while high leverage can be a proxy for agency conflict within a firm, it is also a proxy for financial constraint (Eisfeldt and Rampini, 2007). Hence, as is the case of cash flows, the exact implication of a statistically significant (and negative) coefficient for leverage is not necessarily clear.

In sum, the literature on firm-level investment posits that in a world characterised by perfect capital market and no agency conflicts, investment would depend on Tobin's q and output, the latter a proxy for demand constraint. Once agency conflicts and informational imperfections are introduced, there can be underinvestment on account of paucity of cash flows (a proxy for both optimal/desired capital stock and agency conflict), firm size (a proxy for collateral), leverage (a proxy for both agency conflict and financial constraint), and, in certain contexts, absence of organisational structures such as business groups. We discuss the implications of this for our empirical methodology in the next section.

3. Empirical strategy and data

3.1 Empirical strategy

As mentioned earlier, the literature on investment decisions of firms builds on the work of Fazzari, Hubbard and Petersen (1988), who use Value Line data for 422 large U.S. manufacturing firms over the 1970-84 period. If a value maximizing firm is not financially constrained, its investment decisions depend only on their future prospect, which is captured by Tobin's q. [7] As discussed earlier, it might also be affected by current and past sales. However, if the firm is finance constrained, its investment is also affected by cash flow that is a proxy for internal resources. In the tradition of the literature we characterise the regression model as follows:

[7] For a discussion of the optimisation problem of a value-maximising firm that underpins this specification, see Hubbard (1998).

$$\frac{I_{it}}{K_{i,t-1}} = f\left(\frac{X_{it}}{K_{i,t-1}}\right) + g\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \varepsilon_{it} \qquad [1]$$

where *I* is investment, *X* is vector of variables that captures investment opportunities, *CF* is cash flow, *K* is capital, and ε is the independently and identically distributed (i.i.d.) noise term. In light of our earlier discussion, it is obvious that the components of vector *X* are Tobin's *q* and present and lagged values of sales.

Equation [1] is generally extended, as required, to examine the impact of factors over and above cash flow that can capture frictions in the capital market on investment levels. For example, Aivazian, Ge and Qiu (2005) examine the impact of leverage on firm investment in Canada using the following regression model:

$$\frac{I_{it}}{K_{i,t-1}} = \alpha + \beta\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \delta \ln Q_{i,t-1} + \phi\left(\frac{SALE_{i,t-1}}{K_{i,t-1}}\right) + \rho LEVERAGE_{i,t-1} + \theta_t + \mu_i + \varepsilon_{it} \qquad [2]$$

where θ and μ capture time and firm fixed effects, and ε is the i.i.d error term. As in the case of [1], if the cash flow and leverage coefficients in above regressions are found to be statistically significant, one might argue that firms are finance constrained. While Aivazian et al. (2005) use panel regression models for estimation, some researchers use pooled (ordinary least squares) regression to estimate the model (Lang, Ofek and Stulz, 1996).

In much of the literature, the sample of firms is classified into groups that have differential cost of information, and hence different likelihoods of being financially constrained, on the basis of some criterion. The differences in sensitivity of investment to internal resources (i.e., cash flows) for these groups capture the differences in the extent of credit constraint. The Fazzari, Hubbard and Petersen (1988) paper classified firms on the basis of their dividend payouts, while other studies have used firm characteristics such as size and age. While the basis for the chosen criteria are plausible, it is nevertheless *ad hoc,* especially when the criteria are potentially time varying. Kaplan and Zingales (1997) showed that the cash flow sensitivity to investment could lead to erroneous conclusion when firms are classified into groups of high or low costs of information by dividend pay-out or any other criterion. As discussed in Laeven (2003), *a priori* classification of firms into groups using other criteria might lead to erroneous conclusion as well.

The stochastic frontier approach provides a better way of testing the presence of constraints in the investment function and examining the impact of the constraining variables in investment. Wang (2003) argues that in the absence of agency conflicts and capital market imperfections a firm's investment decision is defined as follows:

$$\ln\left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} = \alpha + \beta \ln Q_{i,t} + \gamma \ln\left(\frac{SALE_{i,t}}{K_{i,t-1}}\right) + \delta \ln\left(\frac{SALE_{i,t-1}}{K_{i,t-2}}\right) + \theta_t + \mu_i + \varepsilon_{it} \qquad [3]$$

where θ, μ and ε have the same interpretation as above. This regression model, therefore, defines the efficient investment function (frontier). In the presence of financing constraints, the observed investment-to-capital ratio will be less than the efficient (optimal) investment-to-capital ratio in [3]. Thus, the difference between this efficient investment-to-capital ratio and the observed investment-to-capital ratio will be attributed to financing constraint. This difference can be represented by a non-negative term u. More specifically, we write the observed investment-to-capital ratio as:

$$\left(\frac{I_{it}}{K_{i,t-1}}\right) = \left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} \exp(-u) \quad \Rightarrow \quad \ln\left(\frac{I_{it}}{K_{i,t-1}}\right) = \ln\left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} - u \qquad [4]$$

Models [3] and [4] together define the stochastic frontier formulation of the investment function. The above model can be estimated using distributional assumptions on u and ε.[8] It gives not only the estimates of the parameters of the investment function but observation-specific estimates of u as well. The first (and perhaps the main) advantage of the stochastic frontier approach is that the

[8] In stochastic production frontier models (Kumbhakar and Lovell, 2000), the frontier function usually represents the production function and the u term represents technical inefficiency. The model estimates both the parameters and technical inefficiency.

estimated (non-negative) values of *u* can tell us not only whether a firm is constrained, but also the degree (severity) of its constraint. The higher the value of *u* greater is the impact of constraints on investment. If *u* is close to zero for some firms we can say that that those firms are not constrained. Thus in the present case, the frontier represents the desired/optimum investment function which is unobserved and the *u* term represents a firm's inability to attain the investment frontier, *ceteris paribus*, due to the presence of financing constraints.

In other words, the main advantage of the stochastic frontier approach is its ability to compute a technical efficiency score for each firm and for each year of the sample period, technical efficiency being a measure of the extent to which a firm is successful in mitigating credit constraints. More specifically, technical efficiency will be investment efficiency defined as the ratio of actual to the efficient investment (i.e., exp(-*u*) which will be bounded between 0 and 1). Thus, for example, an efficiency score of 0.8 indicates that the firm's investment is 80 percent of its desired level. The efficiency score will be estimated for each observation using the frontier technique. It is, therefore, possible to examine distributions of the extent of credit constraints of the firms from the efficiency scores. Aside from the ease of interpretation, the technical efficiency score has the advantage that it captures the combined impact of all the constraining variables on the extent of credit constraint. By contrast, alternative methodologies such as OLS or fixed effects panel data models captures the marginal impact of individual *Z* variables on investment alone, and hence do not tell us whether or not a firm is credit constrained overall, and if so by how much.[9] The technical efficiency score also enables us to identify whether certain types of firms are concentrated more in one of the tails of the distribution of the technical efficiency score – i.e., whether firms with certain characteristics are more likely to be credit constrained – or evenly spread along it, once again, without using any *ad hoc* criteria to split the sample.

[9] This is because in models such as [1] and [2] the difference between the expected values of $\ln(I_{it}/K_{i,t-1})$ with and without the Z variables might not be negative. A negative value for $E(\ln(I_{it}/K_{i,t-1})|_{Z=0})$ − $E(\ln(I_{it}/K_{i,t-1})|_{Z\neq 0})$ can be interpreted as percentage reduction in investment due to the presence of credit constraints (proxied by the Z variables). In other words, although one can show that firms are credit constrained from the marginal effects of the Z variables, it is not possible to quantify the degree of it.

Another advantage of the stochastic frontier approach is that we can directly estimate the impact of firm characteristics (*Z*) such as size and leverage on the degree of credit constraint, once again, without splitting the sample in any *ad hoc* manner. This can be done by extending the basic model proposed above to accommodate the Z variables. We accommodate these variables into the model via the inefficiency term, i.e., we now assume that $u_{it} \sim N(0, \sigma_u^2(Z_{it}))$, $u_{it} \geq 0$ where $\sigma_u(Z_{it}) = \exp(\gamma' Z_{it})$ to maintain non-negativity. Furthermore, we specify $\gamma' Z_{it}$ as

$$\gamma' Z_{it} = \varphi\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \pi LOGASSET_{i,t} + \rho LEVERAGE_{i,t} + \omega GROUP_{it} + \sigma(GROUP_{it} \times TIMETREND) \quad [5]$$

where *LOGASSET* is the logarithm of physical assets (a proxy for ability to post collateral), *LEVERAGE* (the debt-to-equity ratio) is a measure of the firm's financial fragility, *GROUP* is a dummy variable that takes the value one if the firm belongs to a business group, and *TIMETREND* is a variable that has the value one for the first year of the sample period and increases by one for each subsequent year in the sample period. The interaction term involving the group membership dummy and the time trend variable captures the changing impact of business group membership on a firm's credit constraint over time. Finally, γ is the parameter vector associated with these variables.

In essence, we argue that the factors restricting access to capital and credit markets are inability to post collateral and financial fragility. Internal cash flows allow the firm to mitigate the financial constraints. Ability to access external finance increases with a firm's stock of assets that can be posted as collateral, and is adversely affected by high leverage. Finally, we posit that membership of business groups can alleviate credit constraints as well, even though the ability of business groups to alleviate credit constraints might change over time. As discussed earlier in the paper, the choice of these constraining variables is perfectly consistent with the literature on firm investment decisions.

To summarise, if one estimates the investment frontier in [3], the estimated values of *u* will show which firm is investing less and by how much due to the presence of constraints. In [5] we go one step further and assume that investment inefficiency can be explained in terms of the *Z* variables.

In the above specification $E(u_{it}) = \sqrt{2/\pi}\,\sigma(Z_{it}) = \sqrt{2/\pi}\exp(\gamma' Z_{it})$ and hence we can easily find the marginal effect of the Z variables on investment inefficiency. If a Z variable lowers u (i.e., relaxes the financing constraint), the marginal effect will tell us by what percent investment will increase if a Z variable is increased by one percent. Hence, aside from offering the aforementioned advantages over OLS and fixed effects panel data approaches, the stochastic frontier approach also allows us to estimate marginal impact of Z variables, in much the same way as the alternative approaches.

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. Consider, for example, the following variation of [1] which includes the Z variables enumerated in [5]:

$$\ln\left(\frac{I_{it}}{K_{i,t-1}}\right) = \alpha + \beta \ln Q_{i,t} + \gamma \ln\left(\frac{SALE_{i,t}}{K_{i,t-1}}\right) + \delta \ln\left(\frac{SALE_{i,t-1}}{K_{i,t-2}}\right) + \varphi\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \pi LOGASSET_{i,t}$$
$$+\rho LEVERAGE_{i,t} + \omega GROUP_{it} + \sigma(GROUP_{it} \times TIMETREND) + \theta_t + \mu_i + \varepsilon_{it} \quad [6]$$

Next, consider the stochastic formulation of the baseline equation:

$$\ln\left(\frac{I_{it}}{K_{i,t-1}}\right) = \alpha + \beta \ln Q_{i,t} + \gamma \ln\left(\frac{SALE_{i,t}}{K_{i,t-1}}\right) + \delta \ln\left(\frac{SALE_{i,t-1}}{K_{i,t-2}}\right) + \theta_t + \mu_i + \varepsilon_{it} - u_{it} \quad [7]$$

If we denote $v_{it} = \varepsilon_{it} - u_{it}$, it is clear that v_{it} will have a non-zero mean because u_{it} is non-negative, and this poses a problem in using OLS (which will assume zero mean error). This non-zero mean problem can be avoided by rewriting v_{it} as $v_{it} = \varepsilon_{it} - \left(u_{it} - E(u_{it})\right) - E(u_{it}) \equiv \varepsilon^*_{it} - E(u_{it})$ where $E(\varepsilon^*_{it}) = 0$ by construction. We then get an error term that has a zero mean but need to account for the extra term $-E(u_{it})$ in the regression. If we assume that

$$-E(u_{it}) = \varphi\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \pi LOGASSET_{i,t} + \rho LEVERAGE_{i,t} + \omega GROUP_{it}$$
$$+ \sigma(GROUP_{it} \times TIMETREND) \quad [7a]$$

then we get back [6]. Thus, we can justify the use of [6] starting from a frontier model. The advantage of using [7] is that the distributional assumptions about u and v in the stochastic frontier model guarantees that $-E(u_{it}) < 0$, thereby shedding light on the extent of credit constraint of a firm in each of the years of analysis. As discussed earlier in this section, the traditional approaches based on OLS and fixed effects panel models do not offer this advantage.

We use a combination of these methodologies to examine the nature of credit constraints among our sample of firms. Our base model is given by [7], which we estimate using OLS, fixed effects panel model and the stochastic frontier approach.[10] We then extend the model gradually to account for factors that can affect a firm's credit constraint, i.e., the Z variables. Our extended specification for the OLS and fixed effects panel model is given by [6] while the extended stochastic frontier specification is given by [7] and [7a]. From the earlier discussion about the likely impact of the Z variables, it is evident therefore that expected signs of the coefficients of the Z variables are as follows:

	Pooled OLS	Panel fixed effects	Stochastic frontier
Cash flows	+	+	-
(Log) assets	+	+	-
Leverage	-	-	+
Business group membership	+	+	-
Business group membership × Time trend	?	?	?

3.2 Data

We estimate the OLS, panel data, and stochastic frontier models using firm-level data from the Indian manufacturing sector. Our sample includes a set of 598 Indian private manufacturing firms

[10] The OLS and fixed effects panel models, of course, include only the i.i.d. ε term, not the u inefficiency term.

incorporated prior to 1991. We focus on private firms which, unlike many state-owned firms, do not have soft budget constraints on account of access to the public purse (see Majumdar, 1998), and, even though some of the firms have foreign equity participation, they do not have access to global capital market. Our sample of firms are largely dependent on the local credit market to finance their investments which is quite representative for not just Indian firms but privately owned firms in nearly all emerging markets. The choice of firms that were incorporated before 1991 ensures that all the firms in the same had time to develop banking relationships well before the sample period of 1997-2006. Our results should therefore not be influenced by a sub-sample of new firms that are credit constrained on account of weak banking relationships. Finally, the choice of manufacturing firms alone is consistent with a wide range of empirical analyses that do not pool together manufacturing and services sector firms that are different in many ways.

Data on these firms are obtained from the widely used *Prowess* database marketed by the Centre for Monitoring the Indian Economy (CMIE). *Prowess* provides balance sheets and profit and loss accounts of firms in a standardised format, making the numbers comparable across the firms. Data on variables such as sales, capital, investments and cash flows can therefore be directly obtained from the database or easily computed. *Prowess* also provides information on financial ratios such as the debt-to-equity ratio that is our measure of leverage or financial fragility, as well as information on business group affiliations Our definition of variables is consistent with the existing literature.

INSERT Table 1 here.

In Table 1, we report the summary statistics of the variables we use in our regression models. The figures are self-explanatory, and only one variable needs further explanation. We discovered through experimentation that the debt-to-equity ratio of firms, our measure of leverage, does not have an impact on investment decisions or the aforesaid inefficiency when it is used in the relevant regression specification in linear and quadratic forms. This is not surprising; a change in the leverage from (say) 0.2 to 0.3 may not have any impact on a firm's ability to borrow, but an increase from 1.6

to 1.7 might have a significant impact.[11] Indeed evidence suggests that leverage has a threshold effect on credit ratings (Becker and Milbourn, 2008). Hence, as a proxy for leverage, we used a dummy variable that takes the value one when the leverage is high, and zero otherwise. Experimentation with the threshold suggests that leverage adds to financial constraint for threshold values of debt-to-equity ratio beyond 1.6. When the threshold of 1.6 is used, the coefficient of the high-leverage dummy variable is significant at the 10 percent level. The statistical significance of the coefficient improves as the threshold is raised, and it becomes significant at the 1 percent level for threshold values of 1.8 or more. We, therefore, use the cut-off value of 1.8 for our estimation. In our sample, sixteen percent of the firms reported high leverage.

4. Regression results and discussion

The regression results are reported in Tables 2 and 3. In Table 2, we report the OLS estimates and estimates of the panel fixed effects model. For each of these models, we progressively introduce the factors that determine investment in contexts without agency conflicts and market imperfections (Columns 1 and 4), the much discussed cash flow and (log) asset variables that capture a firm's ability to mitigate credit constraints (Columns 2 and 5), and the less discussed leverage and business group membership variables that also affect a firm's investment decisions (Columns 3 and 6). The F-statistics and the R-squared values for the models are reported as well, and they indicate that the specifications are meaningful, and are a reasonably good fit for the data.

INSERT Table 2 here.

In Table 3, we report the estimates of stochastic frontier models with fixed effects. The model in column (1) assumes that investment inefficiency *u* is i.i.d., $N(0,\sigma_u^2), u_{it} \geq 0$ but does not attempt to explain this inefficiency. The models in columns (2) and (3) capture the impact of firm

[11] This argument is not unique to this particular context. For example, while an increase in an investor's ownership from 10 percent of a company to 11 percent may not have any impact on the behaviour or performance of the company, an increase from 49 percent to 50 percent, which gives the investor outright control of the company, may have a significant impact (Bhaumik, Driffield and Pal, 2010).

characteristics on inefficiency. As in the case of the OLS and fixed effects panel models, we introduce the firm characteristics gradually. We include the cash flow and (log) assets variables in column (2), and add the leverage and business group membership variables in column (3).

INSERT Table 3 here.

The regression results suggest that, as expected, Tobin's *q* and investment decisions are generally positively correlated. Current sales too always has a positive impact on investment, while sales lagged one period has a positive coefficient for the panel fixed effect model and most of the specifications of the stochastic model, but negative coefficients for the OLS models. As we have already noted, when sales accelerator is modelled as a function of current and past sales, some of the coefficients may be negative (Abel and Blanchard, 1989). Overall, wherever the sales lagged one period has a negative coefficient, the coefficient of the current sales variable is much larger, and it is reasonable to conclude that sales have a positive impact on investment decisions.

We now turn to the factors that alleviate or aggravate the friction in the capital and credit markets. The coefficients of these variables, reported in Tables 2 and 3, can be summarised as follows:

	Pooled OLS	Panel fixed effects	Stochastic frontier
Cash flows		+	-
(Log) assets	+	+	-
Leverage	-	-	+
Business group membership	+		-
Business group membership × Time trend	-	-	+

It is easily seen than the signs of these coefficients are not only consistent with our expectations, but are also remarkably robust across estimation methodologies and specifications. Specifically,

- Investment is positively correlated with cash flow; conversely, cash flow reduces credit constraints. This is consistent with the mainstream literature on firm level investments.
- Similarly, investment (credit constraint) is positively (negatively) correlated with (log) assets, our proxy for access to collateral. This has significant implications for fast growing firms and service sector firms whose collaterisable assets may be small relative to their investment needs.
- The extent of friction or credit constraint increases with a firm's leverage, signalling perhaps both prudence and risk aversion of the creditors and investors. This is consistent with the available evidence about the risk aversion of Indian banks (Bhaumik and Piesse, 2008).
- The pooled OLS and stochastic frontier estimates suggest that business group membership alleviates credit constraints, which is consistent with the stylised view about internal capital markets associated with these organisational structures. But the negative coefficient of the interaction term involving the time trend indicates that the advantages of belonging to a business group declines over time and disappears by the ninth or tenth year of the sample period, by the end of the first decade of this century. The panel fixed effects results suggest that business group membership aggravated credit constraints throughout the sample period. This is consistent with the argument that while business groups are an optimal response to market failures in various contexts, the disadvantages associated with their opaque structures and questionable corporate governance qualities, as well as resistance to change, might outweigh the advantages once economic reforms liberalise factor and product markets and reduce the difficulty in accessing resources (Bhaumik and Gregoriou, 2010). This result is also consistent with that of Borensztein and Lee (2000), who found that subsequent to the financial crisis in South Korea in 1997, the *chaebol* affiliated firms lost their advantage with respect to access to credit.

INSERT Table 4 here.

The marginal effects for cash flow and (log) assets variables are reported in Table 4. We report the marginal effects of these constraining factors for the 10th, 25th, 50th, 75th and 90th percentiles of their respective distributions. We do not generate marginal effects of the other variables that are binary zero-one indicators of leverage and business group membership. The marginal effects suggest that while cash flow and (log) assets reduce inefficiency, i.e., alleviate credit constraints for firms at all points of their distributions, the marginal impact of both these variables is much higher for firms that are at the lower tails of these distributions. For example, cash flow has a marginal effect of -0.0016 for firms at the 90th percentile of the distribution, but this marginal effect doubles to -0.0032 for firms that are at the 10th percentile of the distribution. Similarly, the marginal effects of (log) assets for the corresponding percentile levels of its distribution are -0.1062 and -0.2104, respectively.

We undertake three other robustness checks for our estimation. First, we recognize the fact that in India long term debt often accounts for a greater proportion of assets than equity. This is especially true for older firms, a lot of whose assets were acquired prior to the growth of the Indian equity market. Following Fazzari, Hubbard and Petersen (1988), we replace the usual measure of Tobin's q with one that takes into account long term debt, i.e., our new measure of Tobin's q is the ratio of the sum of the value of equity and long term debt to the replacement cost of these assets. Second, we take into account the possibility that, aside from Tobin's q and expected sales, investment decisions can be affected by uncertainty (Pindyck, 1991). We use as our proxy for a firm's uncertainty during a given year the variance of stock returns of that firm during that year (Leahy and Whited, 1996; Bulan, 2005). Finally, we replace the debt-to-equity ratio by another measure of financial distress, namely, the solvency ratio.[12] The choice of solvency ratio as a proxy for financial fragility is consistent with the research of Peat (2003) and Gryglewicz (2010). However, none of these changes

[12] Solvency ratio is defined as the ratio of after tax profit plus depreciation to long term liabilities plus short term liabilities and can be used as a measure of the ability of the firm to meet debt obligations. It is, therefore, a proxy for financial fragility.

affects our results. We, therefore, do not report the coefficient estimates associated with these new specifications.

INSERT Figures 1-3 here.

Next, we generate firm- and year-specific measures of technical (investment) efficiency from our stochastic frontier models. To recapitulate, the technical efficiency measure is bounded in (0, 1), with values close to zero indicating a high degree of credit constraint and values close to one indicating very little credit constraint. In order to understand how financial liberalisation and associated corporate restructuring have affected credit constraints of Indian firms, in Figures 1-3 we report the distributions of firm-specific technical efficiency for 1997 and 2006. Figure 1 suggests that while larger firms (in the top quartile of size distribution) were less credit constrained than the smaller firms (in the bottom quartile of the size distribution) in 1997 – distribution of technical efficiency of larger firms shifted to the right of the corresponding distribution for smaller firms – by 2006 the difference between the two types of firms had largely disappeared. Similarly, Figure 3 suggests that while highly indebted firms (those with debt-to-equity ratio higher than 1.8) were more credit constrained than firms with lower level of indebtedness (debt-to-equity ratio less than 1.8) in 1997, any remaining difference is not discernible from the distributions for 2006. However, it is difficult to detect patterns from Figure 2 which graphs the technical efficiency of business group members and non-members.

INSERT Table 5 here.

In Table 5, we report the means and medians of the distributions plotted in Figures 1-3. It is easily seen that the contrast between technical efficiency of larger and smaller firms, and firms with and without a high level of indebtedness was sharper in 1997 than in 2006. By 2006, characteristics such as size and leverage were no longer sufficient to characterise the extent of credit constraints experienced by the firms; the differences in means and medians of the size and leverage classes was negligible. As such, this would suggest that credit market imperfections were reduced by 2006; firms did not require credible signals in the form of assets and low leverage to access credit. At the same time, however, the mean and median technical efficiency of all types of firms were reduced between 1997 and 2006. A plausible explanation for this is that firm-level demand for credit was rising faster than access to credit, as the fast growing economy opened up ever more opportunities for the firms. This explanation is consistent with the findings of Banerjee et al. (2005), namely, that banks in India determine credit in period *t* based on credit sanctioned in period *t-1*, without taking into consideration the growth potential of the firms. It is also consistent with the findings of Marjit and Das (2008).

The summary measures of technical efficiency reported in Table 5 also have implications for corporate restructuring. Business group non-members had higher median (and mean) technical efficiency than their business group member counterparts in 1997, and by 2006 the difference in the median technical efficiency of business group members and non-members had widened further. The technical efficiency figures reported here suggest that as business group membership itself aggravated credit constraints for firms between 1997 and 2006, other characteristics of business group members did not change in a way that could offset this disadvantage. In other words, while business groups persist in the Indian corporate landscape, as in countries like South Korea (Boresnztein and Lee, 2000), the rationale for forming business groups and sustaining corporate structures that incorporate them has weakened since the initiation of financial and other reforms in the early nineties.However, business groups may have other advantages (see Khanna and Palepu, 1999) that are not discussed in this paper.

5. Conclusions

In this paper, we build on the literature on the related issues of firm investment and credit constraints experienced by firms during the process of investment. While there is a fairly large empirical literature on these issues in the context of developed countries, the literature on emerging market economies is relatively sparse. Our paper extends this literature to the context of India, where *prima facie* evidence points towards presence of credit constraints despite significant financial sector reforms since 1992. We adopt the stochastic frontier approach to empirical modelling of firms' investment decisions, which has certain advantages over stylised approaches that use OLS and panel fixed effects models.

Our results suggest that, in keeping with the existing literature in firm-level investments, credit constraints are alleviated by cash flows and (log) assets of firms, and aggravated by a high leverage level. These results are consistent with the literature. We also find that business groups alleviate credit constraints for member firms, but their ability to do so has declined over time. Overall, there is a decline in median investment efficiency of the firms over the sample period, when investment efficiency refers to the ability a firm to translate characteristics such as its Tobin's *q* ratio and sales-to-capital ratio into investment. There was also a sharper decline in the median investment efficiency of business group members increases relative to non-members over the same period.

The decline in median investment efficiency of firms over our sample period has an important policy implication: financial reforms should ease credit constraints, not aggravate them. The next step, therefore, should be an examination of the post-1997 reforms on the lending behaviour of banks.

References

Abel, A. (1980). Empirical investment equations: An integrative approach, Carnegie-Rochester Conference Series on Public Policy, 12(1): 39-91.

Abel, A. and Blanchard, O. (1989). Investment and sales: Some empirical evidence, Working paper no. 2050, National Bureau of Economic Research, Cambridge, Massachusetts.

Abel, A. and Eberly, J. C. (2004). Q Theory without adjustment costs and cash flow effects without financing constraints. 2004 Meeting Papers, Society for Economic Dynamics.

Aivazian, V.A., Ge, Y. and Qiu, J. (2005). The impact of leverage on firm investment: Canadian evidence, Journal of Corporate Finance, 11: 277-291.

Almedia, H. and Campello, M. (2001). Financial constraints and investment-cash flow sensitivities: New theoretical foundations. Working Papers. New York University.

Alti, A. (2003). How sensitive is investment to cash flow when financing is frictionless? Journal of Finance, 58(2): 707-22.

Audretsch, D.B. and Elston, J.A. (2002). Does firm size matter? Evidence on the impact of liquidity constraints on firm investment behaviour in Germany, International Journal of Industrial Organization, 20(1): 1-17.

Banerjee, A., Cole, S. and Duflo, E. (2005). Bank financing in India, In: Tseng, W. and Cowen, D. (Eds). India's and China's Recent Experience with Reform and Growth, Palgrave Macmillan, New York, pp. 138-157.

Beck, T. and Demirguc-Kunt, A. (2006). Small and medium-size enterprises: Access to finance as a growth constraint, Journal of Banking and Finance, 30(11): 2931-2943.

Becker, B. and Milbourn, T. (2008). Reputation and competition: Evidence from the credit rating industry, Working paper no. 09-051, Harvard Business School, Cambridge, Massachusetts.

Bekaert, G., Harvey, C.R. and Lundblad, C. (2005). Does financial liberalization spur growth? Journal of Financial Economics, 77(1): 3-55.

Besanko, D. and Thakor, A.V. (1987). Collateral and rationing: Sorting equilibria in monopolistic and competitive credit markets, International Economic Review, 28(3): 671-689.

Bester, H. (1985). Screening vs. rationing in credit markets with imperfect information, American Economic Review, 75(4): 850-855.

Bhagat, S., Moyen, N. and Suh, I. (2005). Investment and internal funds of distressed firms, Journal of Corporate Finance, 11(3): 449-72.

Bhaumik, S.K., Driffield, N.L. and Pal, S. (2010). Does ownership structure of emerging market firms affect their outward FDI? The case of Indian automotive and pharmaceutical sectors, Journal of International Business Studies, 41: 437-450.

Bhaumik, S.K. and Gregoriou, A. (2010). 'Family' ownership, tunnelling and earnings management: A review of the literature, Journal of Economic Surveys, DOI: 10.1111/j.1467-6419.2009.00608.x.

Bhaumik, S.K. and Piesse, J. (2008). Does lending behaviour of banks in emerging economies vary by ownership? Evidence from the Indian banking sector, Economic Systems, 32(2): 177-196.

Blundell, R. et al. (1992). Investment and Tobin's Q, Journal of Econometrics, 51: 233-257.

Bond, S. and Meghir, C. (1994). Dynamic investment models and the firm's financial policy, Review of Economic Studies, 61(2): 197-222.

Borensztein, E. and Lee, J-W. (2000). Financial crisis and credit crunch in Korea: Evidence from firm level data, Working paper no. WP/00/05, International Monetary Fund, Washington, D.C.

Brown, J.R. and Petersen, B.C. (2009). Why has the investment-cash flow sensitivity declined so sharply? Rising R&D and equity market developments, Journal of Banking and Finance, 33(5): 971-984.

Bulan, L. (2005) Real options, irreversible investment and uncertainty: new evidence from U.S. firms, Review of Financial Economics, 14(3-4): 255-279.

Chaudhuri, A., Koudal, P. and Seshadri, S. (2009). Demystifying investment growth in Indian industries, Mimeo, Deloitte, Downloadable from http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/dtt_sensex_part1%282%29.pdf.

Cuthbertson, K. and Gasparro, D. (1995). Fixed investment decisions in UK manufacturing: The importance of Tobin's Q, output and debt, European Economic Review, 39: 919-941.

Dasgupta, S. and Sengupta, K. (2007). Corporate liquidity, investment and financial constraints: Implications from a multi-period model, Journal of Financial Intermediation, 16(2): 161-74.

Denis, D.J. and Sibilkov, V. (2010): Financial Constraints, Investment, and the Value of Cash Holdings, Review of Financial Studies, 23(1): 247-269.

Devereux, S. and Schiantarelli, F. (1990). Investment, Financial Factors and Cash Flow: Evidence from UK Panel Data, In: R. Glenn Hubbard (Ed.),. *Asymmetric Information, Corporate Finance and Investment*,, Chicago: University of Chicaago Press, pp. 279-306..

Eisfeldt, A.L. and Rampini, A.A. (2007). New or used? Investment with credit constraints, Journal of Monetary Economics, 54: 2656-2681.

Erickson, T. and Whited, T. M. (2000). Measurement error and the relation between investment and Q, Journal of Political Economy, 108(5): 1027-57.

Fazzari, S.M., Hubbard, R.G. and Petersen, B.C. (1988). Financing constraints and corporate investment, Brookings Papers on Economic Activity, Vol. 1, pp. 141-206.

Fazzari, Steven M., and Petersen, Bruce C. (1993). Working Capital and Fixed Investment: New Evidence on Financing Constraints, RAND Journal of Economics, 24(4): 328-41.

Ganesh-Kumar, A. Sen, K. and Vaidya, R.R (2001). Outward Orientation, Investment and Finance constraints: a study of Indian firms, Journal of Development Studies, 37, (4): 133-49.

Gelos, R.G. and Werner, A.M. (2002). Financial liberalization, credit constraints, and collateral: Investment in the Mexican manufacturing sector, Journal of Development Economics, 67: 1-27.

Gomes, J. F. (2001). Financing investment, American Economic Review, 91(5): 1263-85.

Gryglewicz, S. (2010). A theory of corporate financial decisions with liquidity and solvency concerns, Journal of Financial Economics, forthcoming.

Guariglia, A. (2008). Internal financial constraints, external financial constraints, and investment choice: Evidence from a panel of UK firms, Journal of Banking and Finance, 32(9): 1795-1809.

Guncavdi, O., Bleaney, M. and McKay. A. (1998). Financial liberalization and private investment: Evidence from Turkey, Journal of Development Economics, 57(2): 443-55.

Hayashi, F. (1982). Tobin's marginal-Q and average-Q: A neoclassical interpretation, Econometrica, 50(1): 213-224.

Harris, J., Schiantarelli, F. and Siregar, M. (1994). The effects of financial liberalization on firms' capital structure and investment decisions: Evidence from a panel of Indonesian manufacturing establishments, 1981-1988, World Bank Economic Review, 8(1): 17-47.

Hoshi, T., Kashyap, A.K. and Scharfstein, D. (1991). Corporate structure, liquidity and investment: Evidence from Japanese industrial groups, Quarterly Journal of Economics, 106(1): 33-60.

Hubbard, R.G. (1998). Capital market imperfections and investment, Journal of Economic Literature, 36: 193-225.

Hubbard, R.G., Kashyap, A.K. and Whited, T.M. (1995). Internal finance and firm investment, Journal of Money, Credit and Banking, 27(3): 683-701.

Kadapakkam, P-R., Kumar, P.C. and Riddick, L.A. (1998). The impact of cash flows and firm size on investment: The international evidence, Journal of Banking and Finance, 22: 293-320.

Kaplan, S.N. and Zingales, L. (1997). Do financial constraints explain why investment is correlated with cash flow? Quarterly Journal of Economics, 112: 169-215.

Kaplan, S.N. and Zingales, L. (2000). Investment – cash flow sensitivities are not valid measures of financing constraints. Quarterly Journal of Economics, 115: 707-712.

Khanna, T. and Palepu, K. (1999). Policy shocks, market intermediaries, and corporate strategy: The evolution of business groups in Chile and India, Journal of Economics and Management Strategy, 8(2): 271-310.

Khanna, T. and Rivkin, J.W. (2000). Estimating the performance effects of business groups in emerging markets, Strategic Management Journal, 22(1): 45-74.

Khwaja, A.I. and Mian, A. (2006). Do lenders favour politically connected firms? Rent provision in an emerging financial market, Quarterly Journal of Economics, 120(4): 1371-1411.

Koo, J. and Maeng, K. (2005). The effects of financial liberalization on firms' investments in Korea, Journal of Asian Economics, 16(2): 261-97.

Kumbhakar, S.C. and Lovell, C.K.A. (2000). Stochastic frontier analysis, Cambridge University Press.

Laeven, L. (2003). Does financial liberalization reduce financial constraints, Downloadable from http://www.luclaeven.com/papers_files/2003%20Laeven%20Financial%20liberalization%20 FM.pdf.

Lang, L.E., Ofek, E. and Stulz, R. (1996). Leverage, investment and firm growth, Journal of Financial Economics, 40: 3-29.

Leahy, J. and Whited, T. (1996). The effect of uncertainty on investment: some stylized facts, Journal of Money, Credit, and Banking, 28: 64-83.

Lyandres, E. (2007). Costly external financing, investment timing, and investment-cash flow sensitivity, Journal of Corporate Finance, 13(5): 959-80.

Majumdar, S.K. (1998). Slack in the state-owned enterprise: An evaluation of the impact of soft budget constraints, International Journal of Industrial Organization, 16(3): 377-394.

Majumdar, S.K. (2009). Crowding out! The role of state companies and the dynamics of industrial competitiveness in India, Industrial and Corporate Change, 18(1): 165-207.

Marjit, S. and Das, P. K. (2008). Financial Sector Reforms for Stimulating Investment and Economic Growth – The Indian Experience, In: Asian Development Bank (Ed.) *Macroeconomic Management and Government Finances*, New Delhi: Oxford University Press, pp. 131-177,.

Peat, M. (2003). Factors affecting the probability of bankruptcy, Working Paper No. 130, School of Finance and Economics, University of Technology, Sydney, Australia.

Pindyck, R.S. (1991). Irreversibility, uncertainty, and investment, Journal of Economic Literature, 29: 1110-1148.

Povel, P. and Raith, M. (2002). Optimal investment under financial constraints: The roles of internal funds and asymmetric information, AFA 2002 Atlanta Meeting.

Shah, A. and Thomas, S. (1997). Securities markets, In: Parikh, K. (Ed.) India Development Report, Oxford University Press, New Delhi, pp. 167-192.

Shin, H-H. and Park, Y.S. (1999). Financing constraints and internal capital markets: Evidence from Korean ‘chaebols’, Journal of Corporate Finance, 5: 169-191.

Wang, H-J. (2003). A stochastic frontier analysis of financing constraints on investment: The case of financial liberalization in Taiwan, Journal of Business and Economic Statistics, 21(3): 406-419.

Whited, T.M. (1992). Debt, liquidity constraint, and corporate investment: Evidence from panel Data, Journal of Finance, 47(4): 1425-60.

Yoshikawa, H. (1980). On the "q" theory of investment, American Economic Review, 70(4): 739-743.

Table 1
Summary statistics

	Mean	Standard Deviation
(Log) Tobin's q	- 1.06	1.43
(Log) Sales(t)/Capital(t-1)	0.31	0.90
(Log) Sales(t-1)/Capital(t-2)	0.36	0.82
Cash flow(t)/Capital(t-1)	2.25	2.21
(Log) Assets	4.14	1.58
Proportion of firms with high debt-to-equity ratio	0.16	0.36
Proportion of firms with business group membership	0.31	0.46

Table 2
Preliminary regression results

	Ordinary least squares			Panel fixed effects		
	[1]	[2]	[3]	[4]	[5]	[6]
(Log) Tobin's q	0.11 ***	0.11 ***	0.04 **	0.13 ***	0.17 ***	0.12 ***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
(Log) Sales(t)/Capital(t-1)	0.71 ***	0.67 ***	0.67 ***	0.95 ***	0.46 ***	0.44 ***
	(0.05)	(0.04)	(0.03)	(0.03)	(0.05)	(0.05)
(Log) Sales(t-1)/Capital(t-2)	- 0.20 ***	- 0.11 *	- 0.17 ***	0.35 ***	0.54 ***	0.55 ***
	(0.06)	(0.06)	(0.04)	(0.05)	(0.05)	(0.05)
Cash flow(t)/Capital(t-1)		0.005	0.01		. 0.10 ***	- 0.11 ***
		(0.02)	(0.02)		(0.02)	(0.02)
(Log) Assets		0.18 ***	0.17 ***		0.69 ***	0.74 ***
		(0.02)	(0.01)		(0.04)	(0.04)
High debt-to-equity ratio			- 0.30 ***			- 0.29 ***
			(0.07)			(0.06)
Business group membership			0.76 ***			0.23
			(0.14)			(0.82)
Time trend x Business group membership			- 0.07 ***			- 0.07 ***
			(0.01)			(0.01)
Constant	- 3.08 ***	- 3.88 ***	- 3.82 ***	- 3.28 ***	- 6.25 ***	- 6.32 ***
	(0.04)	(0.09)	(0.09)	(0.03)	(0.19)	(0.32)
F-statistic	139.42 ***	114.26 ***	71.62 ***	393.67 ***	302.88 ***	195.98 ***
R-squared	0.17	0.21	0.19	0.15	0.17	0.13
Number of firms	597	597	586	597	597	586
Number of observations	4850	4850	4545	4850	4850	4545

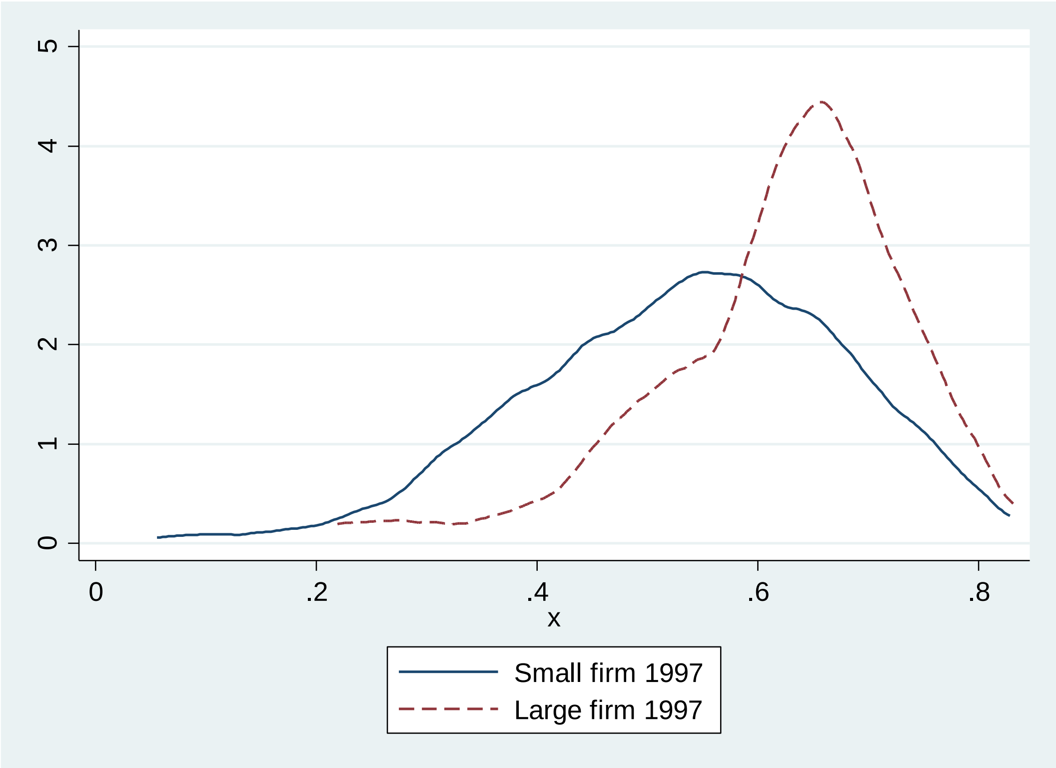
Table 3
Frontier regression models

	Stochastic frontier model		
	[1]	[2]	[3]
Frontier equation			
(Log) Tobin's q	0.11 ***	0.11 ***	0.06 ***
	(0.02)	(0.01)	(0.01)
(Log) Sales(t)/Capital(t-1)	0.77 ***	0.81 ***	0.93 ***
	(0.03)	(0.02)	(0.02)
(Log) Sales(t-1)/Capital(t-2)	- 0.10 **	0.34 ***	0.38 ***
	(0.04)	(0.03)	(0.03)
Constant	- 2.04 ***	- 2.49 ***	- 2.50 ***
	(0.18)	(0.02)	(0.02)
Inefficiency equation			
Cash flow(t)/Capital(t-1)		- 0.27 ***	- 0.10 ***
		(0.06)	(0.03)
(Log) Assets		- 0.07 **	- 0.07 **
		(0.04)	(0.03)
High debt-to-equity ratio			0.21 *
			(0.13)
Business group membership			- 0.62 **
			(0.30)
Time trend x Business group membership			0.07 ***
			(0.03)
Constant		. 0.80 ***	0.58 ***
		(0.18)	(0.18)
Number of firms	597	597	586
Number of observations	4850	4850	4545

Table 4
Marginal effects of *Z* variables

	(*Z*) variables explaining inefficiency	
	Cash flow	(Log) assets
10^{th} percentile	-0.0032	-0.2104
25^{th} percentile	-0.0027	-0.1771
50^{th} percentile	-0.0022	-0.1488
75^{th} percentile	-0.0018	-0.1243
90^{th} percentile	-0.0016	-0.1062

Fig. 1
Impact of size



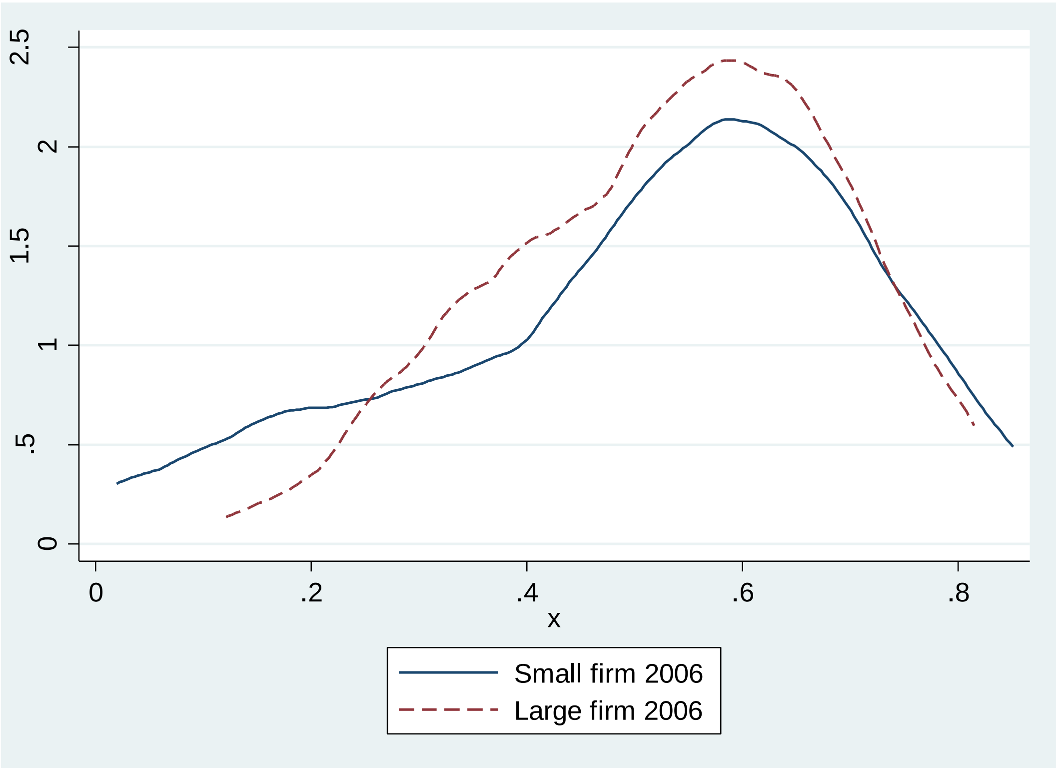


Fig. 2
Impact of business group affiliation

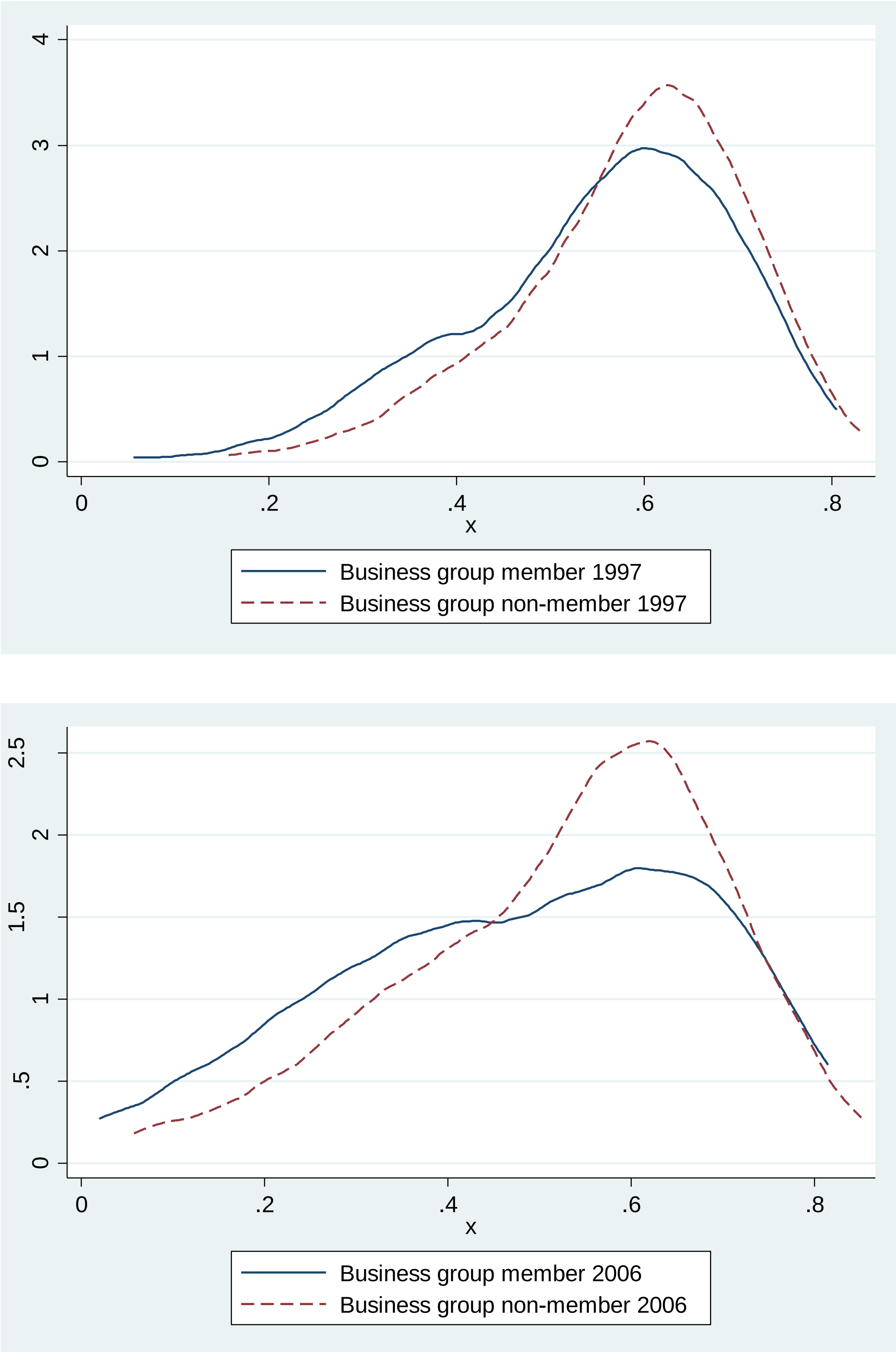
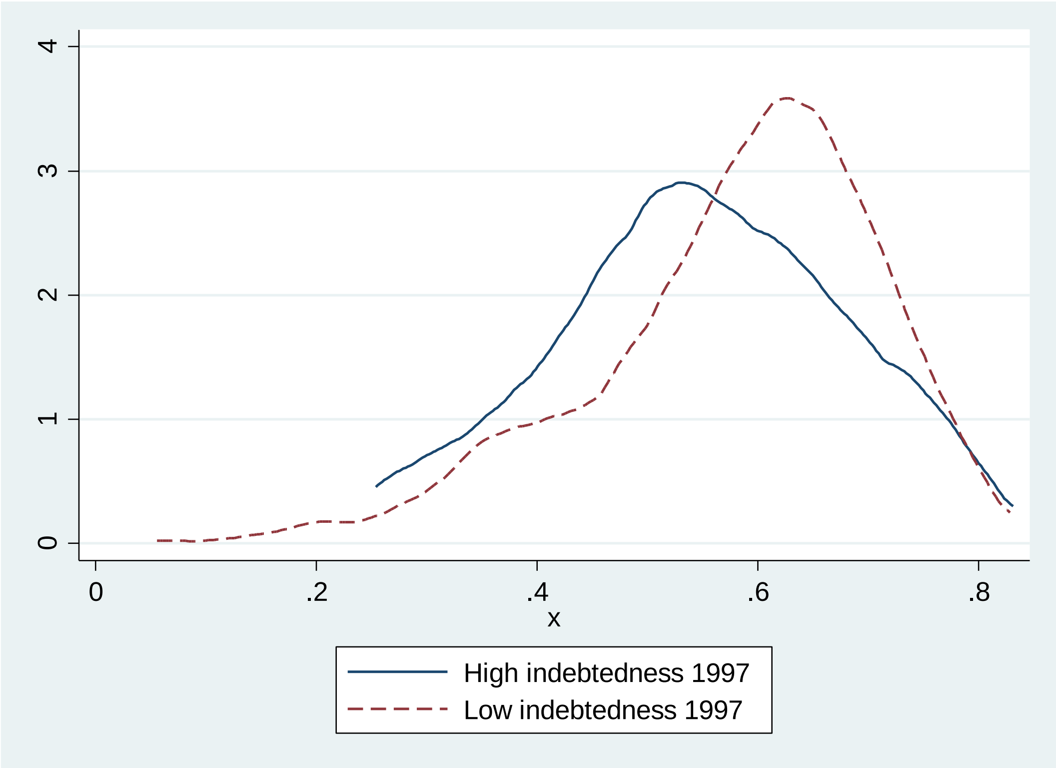


Fig. 3
Impact of indebtedness



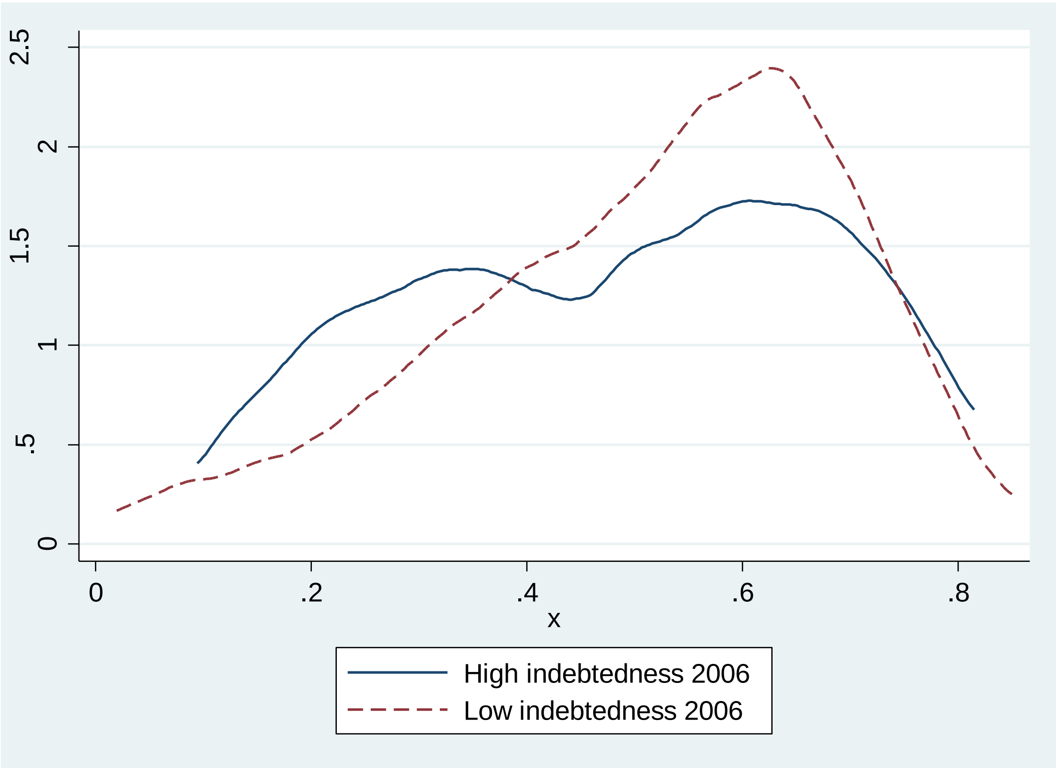


Table 5
Summary statistics for distribution of technical efficiency

	1997		2006	
	Mean (Std. dev.)	**Median**	**Mean (Std. dev.)**	**Median**
Firm size				
Smaller	0.54 (0.14)	0.54	0.50 (0.20)	0.56
Larger	0.62 (0.11)	0.64	0.53 (0.15)	0.55
Business group affiliation				
Affiliated	0.55 (0.14)	0.55	0.48 (0.20)	0.49
Unaffiliated	0.59 (0.12)	0.59	0.52 (0.17)	0.56
Indebtedness				
High	0.55 (0.13)	0.55	0.48 (0.19)	0.52
Not high	0.58 (0.13)	0.60	0.51 (0.17)	0.55

Note: Values within parentheses are standard deviations.

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