Corporate Efficiency, Financial Constraints and the Role of Internal Finance: A Study of Capital Market Imperfection

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A thesis submitted to the University of Sheffield for the degree of Doctor of Philosophy in the Department of Economics

April, 2013

To my parents

Abstract

Drawing on insights from the corporate finance and industrial economics literatures, this thesis combines different empirical strategies and econometric techniques to study the role of capital-market imperfections on the financial and operational activities of firms. The thesis is mainly composed of three different but interlinked empirical chapters as summarized below using an unbalanced panel data on 1122 UK firms listed on the London Stock Exchange during the period 1981 to 2009.

Stochastic Frontier Analysis to Corporate Efficiency : Using the stochastic frontier analysis (SFA), long run and short run corporate efficiencies are predicted in this chapter focusing on value and profit maximization approach respectively. The estimation results reveal that, an average firm in the sample achieves 74.5% of it's best performing peer's market value and 86.6% of it's best performing peer's profit and both of them are highly significant in the analysis. The inverse of these serve as proxies of agency costs and significantly related to the chosen explanatory variables. The general conception that larger firms are more efficient remains valid in this study. The long run market value efficiency supports the agency cost of outside equity and the short run profit efficiency supports the agency cost of outside debt hypothesis. Also there is a positive rank correlation between these two efficiencies which confirms that an average firm in the UK suffers from inefficiency or agency conflicts to a certain extent, no matter whether the firm is driven by short run or long run growth perspectives.

Corporate Efficiency, Credit Status and Investment : The endogenous switching regression models (SRM) incorporating the predicted corporate efficiencies are estimated in this chapter in an effort to clarify the role of cash flow in examining the impact of capital-market imperfections. It is revealed that a financially constrained firm is more likely to be smaller, younger, deficient in capturing better investment opportunities, reserves higher safety stock, pays low dividends, has less collaterizable assets and less external debt. Moreover, a firm's constrained credit status changes with the improvement of it's efficiency. The results further reveal that financially constrained firm's investment is comparatively more sensitive to cash flow, but this sensitivity is negatively and significantly related with corporate efficiency. These results point to the fact that high investment sensitivity to cash flow may not be solely driven by measurement error in investment opportunity, but may still be interpreted as a consequence of imperfect substitutability between internal and external financing arising from the capital market imperfections.

Financial constraints and the dynamics of firm size and growth : Differential quantitative effects of cash flow on growth among firms facing different degrees of financial constraints are found in this chapter using the generalized methods of moments (GMM) estimations and the results are consistent with financial constraints arising from capital market imperfections. The results in general reject Gibrat's "Law of Proportionate Effects" and smaller and younger firms are found to grow faster. The estimated results indicate a substantially greater sensitivity of growth to cash flow for firm years facing the most binding financial constraints on their growth. Furthermore, these firms can actually expand their size more than the extent of increase in cash flow they may have supporting the leverage effect hypothesis. The estimated impact decreases monotonically thereafter as financial constraints become less binding allowing the firms to finance successively bigger portion of their growth through external financing.

JEL classification : C23, C34, D82, G32, L25

Keywords : Asymmetric information, agency costs, market imperfections, corporate efficiency, stochastic frontier, maximum likelihood, financial constraints, internal finance, investment cash flow sensitivity, Tobin's Q, investment opportunity, measurement error, switching regression, law of proportionate effect, liquidity constraint, instruments, growth cash flow sensitivity, leverage effect, GMM.

Acknowledgements

First and foremost, I am grateful to Almighty Allah for giving me the courage to take up the challenge of Doctor of Philosophy degree and the strength to carry on research over three years for it.

I am especially thankful to my supervisors, Professor Karl Taylor and Dr. Anita Ratcliffe for their continuous support, guidance and invaluable suggestions. I am very happy about the way they steered me in my endeavor to complete this thesis, but the responsibility for any errors and omissions remains my own of course. I would like to thank Dr. Michael Dietrich, with whom I initially started my work and I am greatly indebted to him for his generous encouragements. I am also thankful to Dr. Steven McIntosh for his kind support all through, specially during my application and admission to the university. My heartfelt thanks to all the participants in the departmental internal seminars for their comments on different chapters of this thesis.

All the good achievements in my life were because of my parents and for my parents only and my prospective doctorate will not be an exception. I am happy to mention about my little boy here who has been my another source of inspiration since he was born in October, 2011. I would also take this opportunity to thank other members of my family, specially my younger brother for his considerations. Finally, I would like to express my gratitude to all my colleagues and friends in Sheffield for their time and University of Sheffield for the financial support, all of which helped me to survive for an unusually long period away from my home.

Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1 Motivation

Firm efficiency, investment and growth are widely considered as the three most crucial economic dimensions of firm performance, and more importantly, availability and cost of different financing sources are two of the major factors influencing any of these dimensions. The impact of financial constraints on the real activity of firms has remained one of the preferred areas of research in corporate finance and a number of studies explain financial constraints as an important barrier to firm evolution (Fazzari and Athey, 1987, Schiantarelli, 1996, Hubbard, 1998, Stein, 2003). Both theory and empirical evidence suggest that, effects of asymmetric information and agency costs upon lending are not evenly distributed across firms and these imperfections expose some firms to relatively more constrained or rationed access to external financing than others (Hu and Schiantarelli, 1998, Hovakimian and Titman, 2006). Drawing on insights from the literature in corporate finance and industrial economics, this thesis strives to advance our understanding about the role of credit-market frictions in financial and operational activities of firms by exploring the underlying reasons behind firms' heterogeneous performances in terms of the three key economic dimensions mentioned above.

1.2 Background

The classical Modigliani and Miller (1958) approach to financial policy concluded that the financial structure of a firm is irrelevant to both it's value and operating decisions. However, recent literature notes that most firms operate in incomplete and imperfect markets, have limited access to external finance, and need to pay a relatively higher cost for the external funds compared to their internal source. A number of market imperfections arising from asymmetric information and conflict of interests among various stakeholders are considered responsible for invalidating the traditional view and henceforth financial structure of a firm and it's investment decision becomes interdependent. The theoretical foundation of how the investment decision is affected by financial structure under market imperfections is pioneered by the following influential papers. The limited liability of owners-managers in a levered firm induce them to choose too risky projects expecting that their shareholders will get larger benefits if they turn out to be profitable and losses will be inflicted on to debt holders in case of failure (Jensen and Meckling, 1976). Anticipating such behavior, debt holders demand a premium on debt or bond covenants restricting the firm's future use of debt. Underinvestment may also be caused by a moral hazard problem when shareholders have an incentive to abandon profitable investment projects due to the wealth transfer from shareholders to debt holders that occurs whenever the net present value (NPV) of the project is lower than the amount of debt issued (Myers, 1977). Informational asymmetry in the credit market also does not allow lenders to price discriminate between good and bad borrowers in loan contracts, and as a result, a fraction of good investment projects which are not profitable enough to compensate for the excessively high cost of external financing face credit rationing (Stiglitz and Weiss, 1981). A firm's equity financing can also suffer from informational asymmetry problems when the prospective shareholders do not have enough information about the firm value and it's projects (Myers and Majluf, 1984). To cover their potential losses from the adverse selection problem, the prospective shareholders demand a risk premium to purchase the shares of all firms considering the risk of an average investment project. The existing shareholders lose more if the investment projects are undertaken with this costly funding and hence prefer to abandon them. In short, the problems of asymmetric information in the capital market raises the cost of issuing new debt or equity limiting firms' ability or willingness to undertake good investment projects and leads to underinvestment.

Suboptimal investment can also occur due to agency costs between shareholders and management, which arises when the ownership and control of the firms are separated and as a consequence, shareholders' interests are not reflected by management's objective function. In the presence of informational asymmetries, neither the mechanisms devised to align the interests of these two parties may be fully functional nor the monitoring of managerial actions may be done efficiently or cost effectively. In such situations, the availability of cash flow in excess of that required to finance positive NPV projects may lead inefficient managers to increase investment spending instead of distributing the excess funds to shareholders. Such situations occur as the utility managers derive from managing firms has been shown to be an increasing function of the corporations' size because of the associated pecuniary and non-pecuniary benefits (Jensen, 1986, 2001, Bernanke and Gertler, 1989, Stulz, 1990) and therefore, management's corporate objective may be growth rather than value. As a consequence, investments with negative net present value could be undertaken and result in overinvestment. Therefore, moral hazard and adverse selection due to asymmetric information and agency cost due to owner-manager conflicts are the sources behind suboptimal level of investment and prevent firms from achieving their best potential.

Bernanke and Gertler (1989), Calomiris and Hubbard (1990), Gertler (1992), Kiyotaki and Moore (1997), Greenwald and Stiglitz (1993) and Schiantarelli (1996) discuss a variety of methodological issues and provide econometric evidence on the consequences of informational asymmetries on the investment behavior of firms. These models emphasize the costs of adverse selection and moral hazard in generating frictions in the capital markets. The conclusions drawn in these literatures are twofold. Firstly, the effective cost of external financing becomes higher than that of the internal finance unless the loans are fully collateralized and secondly, the premium on such external financing is inversely related to a firm's net worth. The underlying reason for this inverse relationship is that the potential conflict of interests between borrowers and suppliers of external funds is greater when borrowers do not have sufficient funds to contribute to project financing and whenever there occurs a negative shock to a firm's net worth, these conflicts deteriorate further. Therefore, lenders must be compensated with a premium for the risk that borrowers may either misrepresent the quality of a given investment project or behave in a manner that expropriates value from lenders. In general, such risk premium increases with the severity of information asymmetries or difficulty in mitigating the opportunistic behavior (Gilchrist and Zakrajsek, 1995). The higher premium and hurdled access to external financing compel firms to rely more on internal financing sources and result in higher sensitivity of investment to their availability. Hubbard (1998) presents an excellent graphical illustration of these arguments which is reproduced as figure A.1 in appendix A (p. 161).

The debate on whether this high sensitivity of investment to internal financing can be interpreted as an indicator of financial constraints started with Fazzari et al. (1988) and Kaplan and Zingales (1997) who hold completely different views in terms of classifying firms as financially constrained or not and also their investment responsiveness to cash flow. Fazzari et al. (1988) argue that the impact of credit frictions on corporate spending can be evaluated by comparing the sensitivity of investment to cash flow across samples of firms sorted on proxies for financing constraints. They classify low dividend paying firms as most financially constrained which show higher sensitivity of investment to cash flow and vice versa. They also propose the monotonicity hypothesis according to which such sensitivity should increase with the severity of market imperfection. In contrast, Kaplan and Zingales (1997) classify firms without access to more funds than needed as financially constrained. They report that the sensitivity of investment to cash flows is non-monotonic with respect to financial constraints and in particular, it is the lowest for the likely financially constrained firms according to their classification. More recently Moyen (2004) argues that it is hard to identify firms with financial constraints. Using two different unconstrained and constrained firm models, she finds evidence in support of both Fazzari et al. (1988) and Kaplan and Zingales (1997). Cleary et al. (2007) show that the relationship between the firm's internal funds and investment is not monotonic, but U-shaped and with this prediction, explain the contrasting findings of Fazzari et al. (1988) and Kaplan and Zingales (1997). Lyandres (2007) also complements this U-shaped relationship by examining the effects of costly external financing on the optimal timing of a firm's investment. By splitting the sample into groups of firms with different degrees of external financing costs, he finds investment-cash flow sensitivity to be decreasing in the cost of external financing when the latter is relatively low and increasing in the financing cost when it is high. Guariglia (2008) also finds varying investment cash flow sensitivity for internally and externally financial constrained firms. Therefore, it is quite evident from the literature that investment cash flow sensitivity critically depends on the classification criteria or procedure used and this has been considered as one of the reasons for the conflicting findings in the existing literature. Schiantarelli (1996), Hubbard (1998), Lensink et al. (2001), Bond and Van Reenen (2007) provide ample support for this implication.

The above theories and the majority of the empirical evidence focus on the effects of financing constraints on firms' investment, however their effects on firm growth can be quantitatively important as well. This is because if the problems of market imperfection restrict firms' access to lower cost external financing, then such firms may not be successful in pursuing their optimal investment policy and may suffer from lower growth rates in the future (Fazzari et al., 1988, Devereux and Schiantarelli, 1990). There may also be some discernible factors which shape the growth pattern of firms with different credit status as well. A growing literature in industrial economics also postulates that firm size and age are likely to affect firm growth dynamics through two different and inversely directed channels. One of them is that smaller and younger firms are more likely to be at an earlier stage in their development or firm life cycle which can possibly facilitate them to grow faster until they reach some critical or sustainable size. On the contrary, smaller and younger firms are characterized by idiosyncratic risk, less collateral, insufficient track record and weak socioeconomic networks which raise the cost of external capital and limit their access to external financing. Audretsch and Elston (2006) name the first one as "other" and the latter one as "financial-related" size effects and recommend decomposing them to better understand the differences in the dynamics of the size-growth relationship between smaller younger firms and their matured counterparts. Therefore, to evaluate the effects of financial constraints on firm growth, any causal growth regression must be conditioned on firm size, age and productivity differences as well.

1.3 Specific aim

With respect to the investment decision, the major imperfection that has been mentioned is the existence of asymmetric information between the main stakeholders which gives rise to several conflicts among them. In situations where a firm is forced to forego valuable investment opportunities, to participate in uneconomic activities or is exposed to some organizational inefficiencies, the firm's ability to achieve the best practice relative to it's peers will be restricted. Also, it should be carefully considered that a firm's shortfall from the optimal achievable value can be either simply due to random luck beyond the control of the firm's principals or agents rather than influenced by any firm specific reasons and failure to control for this will give a misleading indication. Therefore, it is worthwhile to determine the extent of a firm's underachievement which is solely due to firm specific inefficiencies and that is the first aim of this thesis.

The studies focusing on investment under market imperfections mostly classify firms a priori as financially constrained or unconstrained on the basis of a single and in some cases two quantitative or qualitative indicators that proxy for the informational and agency problems. Then the estimated cross-sectional difference in the sensitivity of investment to internal finance is interpreted as an indicator of the presence of market imperfections. Two crucial points loom over this much debated role of internal financing in an investment equation. One is the difficulty in controlling for the investment opportunities of a firm and the other is the potential static and dynamic misclassification problem. This thesis aims to clarify the role of internal finance in an investment equation by suggesting that sensitivity of investment to internal finance ought to change with capital market imperfections if it is at all linked with these and by taking care of the misclassification issues as well.

Following the growing body of literature investigating the role of financial constraints on firm investment, another strand of empirical studies has sought to identify the effects of financing problems on the size-growth dynamics of firms. These studies mostly start with Gibrat (1931)'s "Law of Proportionate Effects" (LPE) as an empirical benchmark, which plays a remarkable and prominent role in this field of studies. However, the robustness of the existing evidence favoring or rejecting a LPE type of dynamics has been questioned on several methodological grounds like failure to control for financial factors, firm heterogeneity, sample selection etc. The final objective of this thesis is to make a quantitative prediction about the effects of financing problems on the size-growth trajectories of firms within the framework of a Gibrat's regression after tackling the common problems in estimating a dynamic growth equation.

1.4 Structure & methodology

Apart from this prelude and the final concluding chapter, this thesis is divided into three different but interlinked chapters where the outcome of one chapter is used to resolve the problems of the others. Due to the nature and aims of this particular thesis, all the estimations and analysis are based on one single dataset covering the same sample of firms and period. Each chapter is individually structured into different sections, e.g., literature survey, methodology, model specification, description of the variables, empirical results and finally it's own conclusion.

In **chapter 2**, the stochastic frontier analysis (SFA) is used to estimate corporate efficiency of firms. To estimate firm efficiency, a set of firms is considered each of which faces the same opportunity set, but tends to avail this opportunity set in different ways due to diverse firm-specific characteristics such as managerial strengths, technical efficiency and investment choices. By varying the opportunity set and firm characteristics, an optimal value function or frontier function for the sample of firms can be estimated and the smaller the shortfall of a firm from the frontier, the higher is it's predicted efficiency. To distinguish between inefficiency and luck asymmetry, SFA assumes an error term composed of one symmetric random component and another non-symmetric component which enables to estimate a measure of net efficiency. We estimate two different frontiers to predict short run efficiency focusing on the traditional profit maximization approach and long run efficiency focusing on the modern value or wealth maximization approach following the technique pioneered by Battese and Coelli (1995), which allows to explain the inefficiency in terms of various firm related control factors simultaneously. The method of maximum likelihood is used for simultaneous estimation of the parameters of the stochastic frontier and the model for the inefficiency effects.

In **chapter 3**, the predicted corporate efficiency scores are used to identify the divergent investment behavior of endogenously classified constrained and unconstrained firms using the switching regression model (SRM). Each firm at each point of time can face either constrained or unconstrained access to external financing and the probability of facing any of these two is determined by a switching function of variables proxying for firm's financial health, informational and agency problems. The model also simultaneously estimates two separate investment equations for firms across the groups assuming a non-zero coefficient for unconstrained firms' internal finance so that it can capture any residual part of future profitability which may not be property taken into consideration. Given this, if the internal finance coefficient for the constrained firms is still higher than that of the unconstrained ones, then this variation more plausibly indicates the presence of market imperfections. Moreover, if this higher sensitivity for the constrained firms decreases with the improvement of their efficiency, then it more strongly supports the role of internal finance in seizing the effects of capital market imperfections and cannot be nullified on the ground of measurement error issue. The model is estimated by maximum likelihood and calculates the probability of facing a particular financial constraint status for each firm year observations.

In **chapter 4**, attempts are made to determine the differential quantitative effects of internal finance on growth among firms facing different degrees of financial constraints using the generalized methods of moments (GMM) estimator. Even though the main motivation of using switching regression model in chapter three is to overcome the static and dynamic misclassification problems, such a cross sectional method is not suitable for estimating dynamic growth equations as it is expected to suffer from dynamic panel bias and give inconsistent results. Instead, a dummy variable interaction technique is applied to allow the estimated coefficients of internal finance to differ across observations in the different financial constraint categories overriding the need to estimate equations on separate sub-samples of firms. The predicted likelihood index of facing a particular financial constraint status obtained from the switching regression model, which accommodates the necessary features of a good financial constraint proxy by construction, is used in this chapter to create time varying dummy categories to classify firm year observations according to the degree of financial constraints they face. This approach avoids the endogenous selection problem and also allows firms to transit between different financial constraint categories. Furthermore, the GMM estimator controls for unobserved firm-specific heterogeneity and the possible endogeneity of the regressors and hence avoids the bias that arises in this context.

Finally in **chapter 5**, an overall conclusion of this thesis is given. This chapter presents summary and significance of the findings in relation to the aim of this thesis and also gives their limitations and prospects for future studies.

1.5 Data

We have collected data from the Worldscope Database currently owned by Thomson Reuters which describes the database as the financial industry's premier resource of most comprehensive and accurate financial data on public companies resided outside of the United States of America.[1] Worldscope offers annual and interim/quarterly data, detailed historical financial statement content, per share data, calculated ratios, pricing and textual information from the late 1980s for firms in developed markets and is widely respected for content quality, depth of detail, extensive company coverage and content presentation. It provides a standardized format of presentation and uses different templates for industrial, insurance, banks and other financial companies aiming to enhance the comparability of the financial data of companies from different countries, industries and across time. Worldscope is available through a variety of Thomson Financial software products, including Thomson One products, Datastream, and Quantitative

[1] The data definitions and other information about the contents of the Worldscope database are contained in http://extranet.datastream.com/Data/Worldscope/index.htm.

Analytics. For this study, the data were collected through Datastream.

We started with a panel of firms listed in the London Stock Exchange over the period 1981 to 2009. In this primary selection, some firms were accumulated as unclassified and unquoted equities, so we excluded those first. In Worldscope each company is assigned a general industry classification (GIC), which reports whether a company is an industrial (01), utility (02), transportation (03), bank/savings and loan (04), insurance (05) and other financial (06) company. Also the FTSE/Dow Jones Industrial Classification Benchmark (ICB) codes are adopted by the database as it's standard global classification tool and the ICB is much more detailed than the GIC. The ICB structure enables the comparison of companies across four levels of classification, namely 10 industries, 19 supersectors, 41 sectors and 114 subsectors. We managed to collect the 41 sectoral codes against all the firms. We excluded all banks, life and non-life insurance, real estate, general financial, equity and non-equity investment instrument companies according to both the GIC and ICB codes as they follow different accounting practices. This left us with three industries and 33 sectors according to the GIC and ICB codes respectively and these 33 sectors are listed in table A.1 of appendix A (p. 162) along with the industries and supersectors they are in. We also dropped all the observations with unexpected signs, like negative revenue, assets or investment. To avoid loss of firm years, we replaced missing values for intangible assets with zero and created a dummy variable for that considering the significant number of missing observations for intangible assets. Other than this, we dropped all the other observations with missing values for the required variables. Then we deleted all the firms with less than three consecutive years of observations for any of the required variables. Some firms operating for relatively longer period still have gaps in their panels, but have multiple three consecutive observations in them. Finally, the dataset we use in our estimations have an unbalanced panel of 1122 firms from thirty three different sectors with a minimum of three to a maximum of twenty nine consecutive years of observations and a total of 13183 firm-years. As we allow both entry and exit of firms along the way, our estimations using this unbalanced panel data are expected to be free from any potential selection and survivor bias.[2] All required financial variables are deflated with the GDP deflator and all regression variables are winsored at the 1% and 99% level to get rid of the extreme outliers. The latter rule is expected to eliminate observations reflecting very large mergers, extraordinary firm shocks, coding or severe measurement errors and is applied as a common procedure in contemporary finance literatures, e.g., Hovakimian and Titman (2006). Worldscope data items are identified by a five-digit field number and a field name according to which they are collected for this thesis. The data definitions along with their unique identifiers of all the variables used in the three chapters of this thesis are presented in section A.2 of appendix A (p. 164). Each chapter separately reports the mean and distributional information for all the regression variables used in the different empirical models and also explains how those variables are constructed in detail.

1.6 Contributions

In order to appreciate the contributions of this thesis, it is necessary to review the methodologies and limitations of the work that has already been done with similar research interests as of this thesis. In each of the three chapters separately, we have tried to make an up-to-date and comprehensive literature review based on which we have also asserted our contributions to the literature. These are reiterated briefly in this section.

This thesis makes the first contribution by selecting a large panel of UK firms and a long period of time that we consider. Investigating the role of capital market imperfections focusing on the UK firms' performance rather than that of US is important because compared with the amount of work done focusing on the latter economy, comparable UK based studies are few. Our emphasis to estimate short run and long run efficiency and the empirical implications of the distinctions be-

[2] The closest dataset we found to compare with ours is the one used by Carpenter and Guariglia (2008). Allowing entry and exit, they had 902 UK quoted manufacturing companies over 1980-2000 with a total of 10,143 firm-years and a minimum of three consecutive observations before dropping some more observations due to the lagged form of their variables.

tween them are novel. Introducing corporate efficiency in an investment equation to clarify the role of cash flow in detecting the presence of market imperfections is another significant contribution of this thesis. Finally, utilizing the predicted likelihood index from the switching regression model as an indicator of financial constraints to find out the differential quantitative effect of internal finance on firm growth within an augmented Gibrat's equation is another contribution we make to the existing literature. Overall, our composition of different empirical strategies and econometric techniques, provides a distinctive complement to the existing literature by suggesting new ways to study the impact of capital market frictions on firm performance.

Chapter 2
Stochastic Frontier Analysis to Corporate Efficiency

2.1 Introduction

The existence of post-contract asymmetric information between shareholders and bondholders (Jensen and Meckling, 1976, Myers, 1977) and the pre-contract asymmetric information between current and prospective shareholders (Myers and Majluf, 1984) may lead to rejection of some investment projects with a positive net present value (NPV) due to differential cost of internal and external financing. On the other hand, according to agency cost of free cash flow theory (Jensen, 1986), there can be negative NPV investment projects that end up being undertaken. The general perception of these literatures is that, shareholders take too risky projects and misrepresent the quality of the investment project due to their conflict of interest with debtholders and this requires the shareholders to pay higher cost of finance and face higher risk of financial distress, bankruptcy, or liquidation as a result. On the other hand, managers misappropriate firm value due to their conflicts of interest with the shareholders which requires shareholders to bear the cost of providing incentives or monitoring to limit the opportunistic activities of the managers. The first of these two costs is termed as agency cost of outside debt and the latter one as agency cost of outside equity and Jensen and Meckling (1976) defines total agency cost as the sum of these two. Overall, all these market imperfection led inefficiencies are the sources behind suboptimal level of investment and hence may prevent the firms from value or profit maximization (Morgado and Pindado, 2003). Also the paper by Harris and Raviv (1991) gives an extensive review on these problems affecting the financing and investment decisions.

Agency costs can be apparent in various forms like managers exerting insufficient work effort, indulging in executive perks, choosing inputs or outputs or a financial structure that suits their own preferences, firms loosing their credibility to external financiers, forfeiting their ability to undertake profitable investment opportunities in the future etc and all these firm specific factors may cause drop in productivity or loss of profit or value for the firm. At times, firms can also be positively or negatively affected by some external factors which are completely beyond the control of managers or shareholders and a net measure of agency costs must leave out those factors. Moreover, according to the framework of Jensen and Meckling (1976), agency costs incurred by firms can be either zero or positive. Due to their multidimensional nature, it is difficult to measure agency cost in either absolute or relative terms and hence they are largely unquantifiable. Previous studies have used qualitative measures of firm performance based on financial ratios or stock market values or some combination of these, which are regressed on leverage and other control variables for testing the various agency costs hypothesis (Mehran, 1995, Cole and Mehran, 1998, Himmelberg et al., 1999, Florackis and Ozkan, 2009), but have not attempted to calculate the magnitude of agency costs. Also, the two crucial properties mentioned above cannot be accommodated by the empirical methodologies used in these studies and the results are inconclusive as well.

Agency costs arising from the conflict of interests between different stakeholders prevent a firm to achieve the best practice relative to it's peers. Considering that these best practice peers have minimized agency costs, recent developments consider efficiency measurement as closest to the concept of (inverse) agency cost (Berger and Bonaccorsi di Patti, 2006) which is basically how close an individual firm with similar technologies can reach to it's benchmark. This benchmark represents a hypothetical value and the shortfall of the actual firm value from the hypothetical one gives an estimate of the level of inefficiency of the firm. Firms with lower degrees of shortfall, and hence lower inefficiencies, are the more efficient firms. For calculating efficiency in this fashion, stochastic frontier analysis (SFA) is in a number of respects superior to other alternative parametric and non-parametric methods. Several studies have analyzed data with both data envelopment analysis (DEA) and parametric, deterministic frontier estimators (DFA) and have produced mixed evidence. The main disadvantage of DEA method is that there is no provision for statistical noise or measurement error in the model. Under the deterministic frontier specification, random external events or error in the model specification or measurement of the component variables could also translate into increased inefficiency measures. But stochastic frontier is randomly placed by the whole collection of stochastic elements that might enter the model outside the control of the firm. Due to this attractive feature along with the internal consistency and ease of implementation, stochastic frontier is being considered as the standard and most widely accepted econometric technique for efficiency analysis (Greene, 2008).

Therefore, in this paper, we rely on stochastic frontier approach to estimate the corporate efficiency of firms,[3] but from two different perspectives considering that the focus has been shifted from traditional to modern approach in contemporary financial management. The traditional approach focuses on short term horizon and fulfils objective of earning profit. The modern approach focuses on wealth or value maximization rather than profit maximization which gives a longer term horizon for assessment, making way for sustainable performance by businesses. For a business firm, profit should not necessarily be the only objective. It may concentrate on various other aspects like increasing sales, capturing more market share etc, which will take care of profitability. So, it can be said that profit maximization is a subset of wealth maximization and facilitates wealth or value creation. Giving priority to value creation, managers of modern corporations have now shifted to modern approach of financial management which leads to better and true evaluation of business.

Using an unbalanced panel data on 1122 UK firms listed on the London Stock Exchange during the period 1981 to 2009, we estimate two different frontiers considering both the approaches, one on market value and the other on profit to predict firm efficiency following the technique pioneered by Battese and Coelli (1995), which allows to explain the inefficiency in terms of various firm related control factors simultaneously. Efficiency calculated from the market value frontier is termed as long run efficiency and the one estimated from the profit frontier is called short run considering the different maximizing objectives and thus introduces dynamism in the manager shareholder conflicts or agency cost and facilitates comparison between the two. Our work is distinguished by the large

[3]For the purpose of brevity and consistency, we define inefficiencies as the agency costs due to conflicts between shareholders and managers or the agency costs due to conflicts between debt holders and shareholders; define corporate efficiency as an inverse proxy of these inefficiencies and we use these two words interchangeably in this chapter.

and more complete set of firms that we consider. Our emphasis on the empirical implications of the distinction between short run and long run efficiency is also novel. Also, it has been reported in past studies that the corporate governance environment under which the UK companies operate is not disciplined by the market for corporate control (Short and Keasey, 1999, Franks et al., 2001, Köke and Renneboog, 2005) and also the monitoring role of large shareholders, institutional investors and board of directors is limited (Faccio and Lasfer, 2000, Goergen and Renneboog, 2001, Ozkan and Ozkan, 2004). These cause a significant degree of managerial discretion to be present in these firms and for all these reasons, the UK is considered as an excellent choice for agency cost study. So, this makes it an interesting pursuit to study further the agency conflicts and their impact on the level of investment for firms in the UK aiming to make some contribution to the existing literatures.

This chapter is structured into different sections as follows. Section 2.2 draws literature survey, section 2.3 describes the methodology, section 2.4 brings model specification and description of the variables, section 2.5 introduces data and descriptive statistics, section 2.6 presents the empirical results and analysis and finally section 2.7 concludes the paper.

2.2 Literature review

Tests of the agency costs hypothesis typically are based on regressions of measures of firm performance on the equity capital ratio or other indicators of leverage plus some control variables, but the results are inconclusive due to the difficulty in defining a measure of performance close to the theoretical definition of agency costs. For example, Himmelberg et al. (1999) use Tobin's Q, Mehran (1995) uses return on asset and Tobin's Q as well, Cole and Mehran (1998) use stock market price, Ang et al. (2000) use expense ratio and asset utilization ratio, Florackis and Ozkan (2009) use asset turnover ratio and selling, general and administrative expense ratio as proxies for firm performance. The tests using these traditional measures of firm performance based on financial ratios and stock market values may be confounded by factors that are unrelated to agency costs due to the measurement problem mentioned earlier. Also, the empirical strategies used in these studies do not allow to calculate the extent of firms' performance shortfall due to agency costs by setting a separate benchmark for each of them. Ang et al. (2000) provide an estimate of such shortfall in small corporations where 100% manager-owned firms constitute the zero agency cost benchmark and any deviations of expense and efficiency ratios from this benchmark measures the agency cost. But there is no obvious benchmark like that for large firms against which a firm's actual value can be judged as 100% manager ownership is quite improbable in large corporations.

In these respects, efficiency measures are considered closer to the theoretical definition of agency costs as they have provision to control for firm-specific factors outside the control of management and to define a standard performance for the firms which they would be expected to achieve under minimum agency costs (Berger and Bonaccorsi di Patti, 2006). Estimates of efficiency often vary substantially across studies according to the data source, as well as the efficiency concepts and measurement methods used in the studies. At least three definitions of efficiency measures may be recalled from the literatures: (i) technical efficiency which implies maximizing output from a given combination of factors; (ii) allocative efficiency which refers to minimizing costs of the input mix, at given relative prices, for any output level; (iii) revenue efficiency which is related to the maximization of value added, gross earnings or any other financial parameters. However, there is really no consensus on the preferred method for determining the best-practice frontier against which relative efficiencies are measured. The individual studies simultaneously differ from one another in so many different dimensions that it is hard to track the sources of differences in efficiency across firms (Berger and Mester, 1997).

Berger and Bonaccorsi di Patti (2006) examine the bi-directional relationship between capital structure and firm performance by using a parametric measure of profit efficiency as an indicator of (inverse) agency costs for evaluating US commercial banks' performance from 1990 through 1995. This accounts for how well managers raise revenues as well as control costs or how close a firm is to earning the profit that a best-practice firm would earn facing it's same exogenous conditions. To measure net efficiency, they use the distribution-free method over the six-year period that tends to average out random error. However, they acknowledge that profit efficiency measures are imprecise and may embody some measurement error if the profit function is not perfectly specified and the random error does not average out completely. A similar study is conducted by Margaritis and Psillaki (2007) on a sample of 12,240 New Zealand firms to analyze the effect of leverage on firm performance as well as the reverse causality relationship. But, they prefer to calculate technical efficiency and their frontier is based on non-parametric data envelopment analysis (DEA) and provides evidence supporting the positive effect of leverage on efficiency over the entire range of observed data, but the effect of efficiency on leverage is found to be positive at low to mid-leverage levels and negative at high leverage ratios.

Stochastic frontier analysis also provides a way to benchmark the relative value of each firm and allows for a distinction between random elements beyond the control of the firm and agency costs. Motivated by the above idea, Aigner et al. (1977) and Meeusen and van Den Broeck (1977) pioneered stochastic frontier analysis (SFA). The literature on stochastic frontier estimation has grown vastly since then and has been widely used in economic studies of productivity and technical efficiency in hospital costs, airport, electric power, commercial fishing, farming, manufacturing of many sorts, public provision of transportation and sewerage services, education, labor markets, and a huge array of other settings. An extensive survey of the underlying models, econometric techniques and empirical studies can be found in Kumbhakar and Lovell (2003) and Fried et al. (2008). A substantial research effort has also gone into measuring the efficiency of financial institutions, particularly commercial banks. Berger and Mester (1997) documents 130 studies (24 of which use SFA) on financial institutions' efficiency, using data from 21 countries, from multiple time periods, and from various types of institutions including banks, bank branches, savings and loans, credit unions, and insurance companies. Wang (2003) follows SFA in a different approach to calculate investment efficiency index using liquidity augmented Tobin's Q investment model and this index measures the extent to which a firm's rate of investment is close to the frictionless and deterministic level. Using data on Taiwanese manufacturing firms between 1989 and 1996, he tries to identify and quantify the effects of financing constraints on the level of investment.

However, the use of stochastic frontier analysis in capital market studies is relatively new. Stochastic frontier analysis is utilized by Hunt-McCool et al. (1996) to analyze IPO under-pricing and also by Annaert et al. (2003) to judge mutual fund under performance. A new initiative in this field has been taken by Habib and Ljungqvist (2005), Pawlina and Renneboog (2005) and Nguyen and Swanson (2009) who use SFA to compute an estimate of the magnitude of agency costs by comparing a firm's actual Tobin's Q with it's best performing benchmark Q. The question whether a firm's managers maximize value is rephrased by Habib and Ljungqvist (2005) as follows: whether the firm trades at a Tobin's Q that is as high as it could be, i.e. Q* if all operating and investment decisions were made optimally. This benchmark Q* should hold a firm's opportunity set and characteristics constant and it should be stochastic. By varying the opportunity set and firm characteristics, a frontier function can be traced that gives the maximum Q observed in a sample for any combination of opportunity sets and firm characteristics. A firm whose actual Q plots below the frontier, falls short of it's best performing peer valuation and the ratio (Q / Q*) can be used as a size neutral measure of inefficiency or agency cost. Using a panel of 1307 US quoted firms in the S&P Super Composite Index from 1992 to 1997, Habib and Ljungqvist (2005) find that the average firm in their sample attains a value that is 16% below it's benchmark value and they consider that as a measure of agency cost in U.S. corporations. Simultaneously, they relate the shortfall from the benchmark to measures of managerial incentives, controlling for firm differences in the costs of solving the agency problem. The same approach is used by Pawlina and Renneboog (2005) on 985 firms listed on the London Stock Exchange from 1992 to 1998 and their finding is that the market value of an average firm could be increased by 18.2% (15.4% below the benchmark) if all it's resources were used efficiently or agency cost can be minimized.[4] They find positive effect of insider and outsider shareholding on inefficiency and their interpretation for this is that, firms subject to managerial entrenchment are on average less efficient and this problem is exacerbated by the presence of outside block shareholders (financial institutions, the government, and industrial firms) at high levels of ownership.[5] And finally in the study by Nguyen and Swanson (2009) on 49 industries listed in NYSE, AMEX and NASDAQ from 1980 to 2002, the average efficiency for the entire sample is 70% (30% below the benchmark), however Tobin's Q has been log normalized by them.

In comparison to the production frontier approach mentioned above, Weill (2008) adopts cost efficiency measure which shows how close a firm's actual cost is to it's optimal for producing the same bundle of outputs. He uses frontier efficiency scores to evaluate the relationship between leverage and corporate performance in seven European countries. Using a sample of 11836 manufacturing companies from seven European countries including Belgium, France, Germany, Italy, Norway, Portugal and Spain, he estimates stochastic cost frontier and simultaneously an equation relating cost inefficiency to leverage, tangibility, inventory and size for each country in his sample.[6] The results reveal a positive relationship between leverage and corporate performance across five countries and negative in the remaining two.

Besides Pawlina and Renneboog (2005), a few of the UK based studies with particular interest in the capital market and agency costs can also be recalled here. In contrast to using market value frontier to measure efficiency, Amess and Girma (2009) use an empirical model to evaluate the effect of efficiency on the

[4]They use a balanced panel of firms listed on London Stock Exchange, excluding bank, insurance and other financial firms and retaining agricultural, mining, forestry, fishing, construction, manufacturing, retail, wholesale and service firms.

[5]Estimated coefficients of both these variables in their inefficiency equation are hardly significant, but the likelihood ratio (LR) test indicates that they are overall significant in explaining the inefficiency effect.

[6]To do that, he includes interactive terms for each explanatory variables with a dummy for each country in the inefficiency equation.

market value. They use stochastic frontier production approach to estimate technical efficiency involving revenue, number of employees and fixed assets. Using an unbalanced panel of 706 public limited companies observed over the period 1996-2002, they estimate technical efficiency of 54% for the service sector and 51% for the manufacturing sector. However, they also use productive efficiency estimated by the DEA technique and labor productivity as alternative measures of firm efficiency and all these three measures are found to have positive effect on the market value of the manufacturing firms only. Amess (2003) finds positive transitory effect of management buyouts (MBOs) on firm level technical efficiency using the stochastic production frontier approach on a panel of UK manufacturing firms as well. Florackis and Ozkan (2009) employ asset turnover ratio as an inverse proxy and selling, general and administrative expense ratio as a direct proxy for agency costs to test the relationship between managerial entrenchment and agency costs for a sample of 587 UK firms over the period 1999-2005. To measure managerial entrenchment, they employ principal component analysis to combine ownership concentration, board structure, type of block holders and voting power of major shareholders as corporate governance indicators and executive ownership and executive compensation as proxies for managerial incentives. Their dynamic panel data analysis shows that there is a positive relationship between managerial entrenchment and agency costs.

For this study, we stick to the stochastic frontier analysis to measure net efficiency as a firm's relative position to it's frontier can be affected by random luck irrespective of manager's effort. The variables exposed to the market volatility are expected to suffer from measurement error problem which is also not likely to have an effect upon the measure of efficiency by construction. We believe that our measures of corporate efficiency from two perspectives can be used as reasonable (inverse) proxies for all the market imperfections related firm specific problems, like agency conflict, technical or managerial inefficiencies, financial distress etc and their imposed costs on the firms.

2.3 Methodology

To estimate firm efficiency, a set of firms is considered each of which faces the same opportunity set. Obviously due to diverse firm-specific characteristics such as managerial strengths, technical efficiency and investment choices, different firms tend to avail this opportunity set in different ways and therefore create different firm values. The logic implies that firms with higher valuations are the ones generating more value per unit of assets and consequently, the market perceives them to be the more efficient firms. On the other hand, firms with lower valuations are the ones not making the best use of their assets. Hence, they are regarded as the less efficient firms. By varying the opportunity set and firm characteristics in a sample of any combination of firms, an optimal value function or their frontier function can be estimated. The intuition behind the SFA is that a point on the frontier represents the maximum value that a given firm can obtain given it's fundamentals and no inefficiencies and each firm's shortfall from the frontier is an approximate indicator of the perceived firm inefficiency by the market. The smaller the shortfall from the frontier, the higher will be the efficiency. Before estimating the optimal value or the frontier, the following important points must be noted as suggested by Nguyen and Swanson (2009):

First, as the frontier function gives the optimal value achievable by the firms, it is only possible that firms can lie on or below the frontier, but not over it.

Second, the benchmark optimal achievable value is hypothetically derived by an econometric estimation over the best performing companies facing a specific opportunity set, but the true optimal value for a particular firm remains unobserved.

Third, a firm's shortfall from the optimal achievable value can be either simply due to random luck rather than superior management or foresight and so unrelated to any firm specific reasons.

Therefore, it is important to be able to distinguish between actual inefficiency and the random elements beyond the control of the firm's principals or agents. As explained earlier, determination of an efficiency score based on the technique of SFA can discriminate between both the inefficiency and luck asymmetry and enables us to estimate a measure of net inefficiency. To distinguish between the two, SFA assumes an error term composed of two components. One is a symmetric random component capturing measurement error, random shocks and omitted variables and the other is a non-symmetric component representing systematic shortfall from the frontier or inefficiency. Unfortunately, standard ordinary least squares (OLS) cannot distinguish between these two as the inefficiency component is incorporated into the intercept in OLS and is therefore unidentifiable. In contrast, the non-symmetric inefficiency in SFA appears as skewness in residuals, which can be computed for each firm and ranked accordingly. This is what makes this technique more appealing in the inefficiency or agency cost analysis.

Using conventional panel data notation, Y can be expressed as a function of a (1xk) set of explanatory variables X which determines the location of the frontier, and the composite error term ϵ. Here Y represents the market value or profit to be maximized in this study.

$$Y_{it} = X_{it}\beta + \epsilon_{it} \tag{2.1}$$

And

$$\epsilon_{it} = \nu_{it} - u_{it} \tag{2.2}$$

Where β is a (kx1) vector of unknown coefficients to be estimated, i=1,......,N firms and t=1,.....,T years. The location of the frontier is allowed to shift by virtue of the time dependence of the X variables. Here, ν_{it} is a random variable which is assumed to be independently and identically distributed, N $(0, \sigma_\nu^2)$ and allows for estimation errors in locating the frontier itself, thus preventing the frontier from being set by outliers. The error term $u_{it} \geq 0$ permits the identification of the frontier, by making possible the distinction between firms that are on the frontier ($u_{it} = 0$) and firms that are strictly below the frontier ($u_{it} > 0$) and magnitude of this variable u_{it} corresponds to the shortfall in a firm's actual valuation from the potential. By assumption, this $u_{it} \geq 0$ measures the net inefficiency that the firm incurs as a result of misalignment of the stakeholders' objectives and can be related to factors explaining the inefficiency or agency cost. $cov(\nu_{it}, u_{it}) = 0$ restricts the stochastic error ν_{it} around the frontier to be independent of the firm inefficiencies u_{it}. The main advantage of this econometric approach is that the symmetric random component ν_{it} takes account of the effects of factors beyond the control of the managers, any measurement error or omitted variables by taking them away from the estimates of inefficiencies. The parameters of the stochastic frontier and the inefficiency models can either be estimated by using joint maximum likelihood or by a two step approach, given appropriate distributional assumptions.

The two stage estimation procedure, in which the first stage involves the specification and estimation of the stochastic frontier function and the prediction of the inefficiency effects, under the assumption that these inefficiency effects are identically distributed. The second stage involves the specification of a regression model for the predicted inefficiency effects, which contradicts the assumption of identically distributed inefficiency effects in the stochastic frontier. This two stage procedure is used by a number of empirical studies (Pitt and Lee, 1981, Kalirajan, 1981) and has long been recognized as a useful exercise. But this procedure has also been criticized for it's assumption regarding the independence of the inefficiency effects in the two estimation stages.

The above estimation procedure is unlikely to provide estimates which are as efficient as those that could be obtained using a single stage estimation procedure. Kumbhakar et al. (1991) and Reifschneider and Stevenson (1991) propose a stochastic frontier model for cross sectional data in which the inefficiency effects (u_i) are expressed as an explicit function of a vector of firm specific variables and random error. The parameters of the stochastic frontier and the inefficiency model are estimated simultaneously, given appropriate distributional assumptions. Battese and Coelli (1995) propose a similar model for panel data and according to their model specification, u_{it} is assumed to be obtained by truncation at zero of N (m_{it}, σ_u^2).

$$u_{it} = Z_{it}\delta + w_{it} \tag{2.3}$$

$$m_{it} = Z_{it}\delta \tag{2.4}$$

where, Z_{it} is a (1xp) set of variables which may influence the inefficiency of the firms and w_{it} is obtained by truncation of $N(0, \sigma_u^2)$ such that the point of truncation is $-Z_{it}\delta$, i.e., $w_{it} \geq Z_{it}\delta$. δ is a (px1) vector of unknown coefficients to be estimated, and w_{it} denotes the unexplained component of u_{it}. Z_{it} may include some input variables in the stochastic frontier, provided the inefficiency effects are stochastic. The u_{it} and their determinants Z_{it} are allowed to vary over time, accommodating changes in a firm's position relative to the frontier over time and this captures the dynamics of the managers and shareholders conflicts. The time variant inefficiency effect is expressed as $u_{it} = exp\{(-\eta(t - T_i)\}u_i$, where η is the decay parameter to be estimated and T_i is the last time period in the respective panel.

The Battese and Coelli (1995) model uses the parameterizations of Battese and Corra (1977) where $\sigma^2 = \sigma_\nu^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/(\sigma_\nu^2 + \sigma_u^2)$. The method of maximum likelihood is proposed for simultaneous estimation of the parameters of the stochastic frontier and the model for the technical inefficiency effects. The likelihood function of the model is presented in the appendix in the working paper of Battese and Coelli (1993). It is evident from the earlier discussion that, firm i maximizes Y at time t if and only if it is on the frontier or in other words $u_{it} = 0$. If $u_{it} = 0$ for all i and t, then $\sigma_u^2 = 0$. This will make the likelihood function of the SFA specification identical to the OLS likelihood function. But if $u_{it} > 0$ for sufficiently many i and t, then SFA specification will lead to a likelihood gain because OLS wrongly restricts $\sigma_u^2 = 0$. Whether any form of stochastic frontier function is required at all can be checked by testing the significance of the γ parameter, which facilitates a comparison of random variables u_{it} and ν_{it} and must lie between 0 and 1. If γ is zero then the variance of the inefficiency term σ_u^2, here interpreted as the variance of inefficiency is zero and the model reduces to the traditional mean response function. This would indicate that the u_{it} term should be removed from the model, leaving a specification with parameters that can be consistently estimated using ordinary least squares. On the contrary, as γ approaches one, then the deviations from the frontier are characterized more so by inefficiency or agency costs rather than white noise. A likelihood ratio test can also be used to check the presence of inefficiency effect or the one sided error which basically corresponds to testing whether the OLS and the SFA functions are identical. LR statistic for this test follows a mixture of χ^2 distributions, critical values of which can be obtained from table 1 of Kodde and Palm (1986). The degrees of freedom of this statistic equals the number of parameters used to parameterize the distribution of u_{it}. The null hypothesis to be tested is $\gamma = \delta_0 = \delta_1 \cdots = \delta_k = 0$ and the rejection of the null hypothesis confirms that the inefficiency effects are stochastic and are related to the chosen explanatory variables in the Z_{it} vector.

Firm specific effect (f_i) and the aggregate time effect (τ_t) should also be included in the model. As the measure of u_{it} is based on the composite error term and the composite error term is in turn influenced by the parameter estimates of the frontier function, failure to include firm and time specific effects in a panel stochastic frontier model is likely to bias the estimate of u_{it} (Kumbhakar, 1991, Kumbhakar and Hjalmarsson, 1995). The problem of confounded inefficiency measurement with individual-specific effects which may not be related to inefficiency can be avoided in the panel stochastic frontier model, especially when the inefficiency measurement is allowed to vary over time in a parametric form (Cornwell et al., 1990, Kumbhakar, 1990). Because of the truncated error distribution, first difference or mean difference technique cannot be applied to eliminate the effects as differenced truncated normal distributions do not result in a known distribution (Wang, 2003). So, the composite error term in equation (2.2) will actually be like the following:

$$\epsilon_{it} = \nu_{it} - u_{it} + f_i + \tau_t \tag{2.5}$$

Once the parameters have been estimated and the location of the frontier is identified, computation of the efficiency score is straightforward. Specifically, for each firm, the relative distance from the frontier or firm i's predicted efficiency at time t can be measured as follows:

$$\widehat{PE}_{it} = \frac{E(Y_{it}|\widehat{u}_{it} > 0, X_{it})}{E(Y^*_{it}|\widehat{u}_{it} = 0, X_{it})} \tag{2.6}$$

The prediction of the efficiency is based on it's conditional expectation, given the model assumption. The efficiency score, PE, is a normalized measure between 0 and 1. A score of .85 means that the firm achieves 85% of it's best-performing peer's market value or profit given other things constant. If a second firm achieves only 70%, then the market will consider the second firm as less efficient or suffering from higher agency cost compared to the first.

Maximum-likelihood estimates of the parameters of the model are obtained using the computer program Frontier 4.1, which is specially written by Tim Coelli to provide maximum likelihood estimates of the parameters of a number of stochastic production and cost functions.[7] The program accommodates unbalanced panel data and assumes firm effects that are distributed as truncated normal random variables. It has the most flexible options available in terms of modeling the stochastic frontier model and allows individual level efficiency estimates to vary over time. The program Frontier 4.1 follows a three step procedure in estimating the maximum likelihood estimates of the parameters of a stochastic frontier production function. First an OLS estimation of the functions is obtained and then a two-phase grid search of γ is conducted, with the β parameters set equal to the OLS values. The values selected in the grid search are then used as starting values in an iterative procedure (using the Davidson-Fletcher-Powell Quasi-Newton method) to obtain the final maximum likelihood estimates (Coelli, 1996).

[7] ***frontier*** package in Stata can be used to estimate our desired model specification, but that cannot be used on panel data. There is also one package for panel data, ***xtfrontier***, but that does not allow to estimate the inefficiency equation simultaneously with the panel frontier.

2.4 Model Specification

2.4.1 Market value frontier

Tobin's Q represents the future investment growth opportunity in a firm and a firm which is trying to maximize the Tobin's Q or market value focusing on the modern approach of financial management, can be considered to be optimizing it's growth prospect for a sustainable business performance. As described earlier, if a firm's managers aim to maximize the value of the firm by making optimal and persistent operating and investment decisions, then the firm can achieve a Tobin's Q that is as high as it could be. There will be less misalignment of interest among managers, shareholders and debtholders and the market will perceive this firm as efficient considering it's long run growth objective. The efficiency estimated from this perspective can so be termed as long run efficiency. To construct a theoretical benchmark value for each firm controlling for firm characteristics and opportunity set, a market value frontier can be estimated by the following equation, where the determinants of Q have been chosen based on underlying theory and the results established in prior literature. For example, Himmelberg et al. (1999) develop an empirical model to estimate the effect of managerial ownership on firm performance, where they regress Tobin's Q on a number of explanatory variables associated with the scope for managerial discretion or moral hazard, namely, size, capital intensity, profit margin, R&D intensity, advertising intensity and gross investment rates. We try to control for all these along with a few more variables.

$$
\begin{aligned}
Tobin's\ Q_{it} = {} & \beta_0 + \beta_1 Size_{it} + \beta_2 Size^2_{it} + \beta_3 Leverage_{it} \\
& + \beta_4 Capital\ expenditure_{it} + \beta_5 Intangible\ assets_{it} \\
& + \beta_6 Tangibility_{it} + \beta_7 Tangibility^2_{it} + \beta_8 Dividend_{it} \\
& + \beta_9 Firm\ risk_i + \beta_{10} Profit\ margin_{it} + \nu_{it} - u_{it} + f_i + \tau_t \qquad (2.7)
\end{aligned}
$$

After log transformation, the above equation turns to the following, where market value, size and asset base are in natural logarithm form. The asset base or the log of book value of total assets is a control factor from the log transformation of Tobin's Q. The variables with many zero observations are scaled by total assets instead of log transformation to avoid losing observations following Nguyen and Swanson (2009). Log transformation is commonly used in SFA and is expected to reduce the skewness of the sample. As we have a total of 1122 firms, so rather than including dummy for each individual firm to capture the firm fixed effect, the frontiers are estimated with sector dummies based on the assumption that firm characteristics will be similar within each of the 33 sectors classified by the FTSE/Dow Jones Industrial Classification Benchmark (ICB) codes. Year dummies are included to capture year specific effects.

$$\begin{aligned} Market\ value_{it} = {} & \beta_0 + \beta_1 Size_{it} + \beta_2 Size^2_{it} + \beta_3 Leverage_{it} \\ & + \beta_4 Capital\ expenditure_{it} + \beta_5 Intangible\ assets_{it} \\ & + \beta_6 Tangibility_{it} + \beta_7 Tangibility^2_{it} + \beta_8 Dividend_{it} \\ & + \beta_9 Firm\ risk_i + \beta_{10} Profit\ margin_{it} + \beta_{11} Asset\ base_{it} \\ & + \nu_{it} - u_{it} + f_i + \tau_t \end{aligned} \tag{2.8}$$

2.4.2 Profit frontier

On the other hand, profit efficiency evaluates how well managers raise revenues as well as control costs which settles how close a firm is to earning the profit that a best-practice firm would earn facing the same exogenous conditions. The closer is a firm's profit to it's best performing peer, the lower will be the inefficiency or agency costs. The reason why profit efficiency can be a reasonable (inverse) proxy for the agency cost is that the conflicts between debt holders and shareholders may raise the cost of funding for the firm and may also affect other input or output choices if the resources are misallocated due to aberrant managerial behavior. These may reduce profits relative to a best-practice firm and hence reduce profit efficiency. Efficiency estimated from this short run profit maximizing motive, can be termed as short run efficiency. For the profit efficiency, the equation no (2.7) above is rearranged as follows:

$$\begin{aligned} Profit\ margin_{it} = \beta_0 &+ \beta_1 Size_{it} + \beta_2 Size_{it}^2 + \beta_3 Leverage_{it} \\ &+ \beta_4 Capital\ expenditure_{it} + \beta_5 Intangible\ assets_{it} \\ &+ \beta_6 Tangibility_{it} + \beta_7 Tangibility_{it}^2 + \beta_8 Dividend_{it} \\ &+ \beta_9 Firm\ risk_i + \beta_{10} Tobin's\ Q_{it} + \nu_{it} - u_{it} + f_i + \tau_t \end{aligned} \tag{2.9}$$

2.4.3 Inefficiency

The following inefficiency equation is estimated simultaneously with each of the frontier equation given the appropriate distributional assumptions explained earlier and here as well the explanatory variables are chosen based on earlier literatures.

$$\begin{aligned} u_{it} = \delta_0 &+ \delta_1 Size_{it} + \delta_2 Size_{it}^2 + \delta_3 Leverage_{it} + \delta_4 Firm\ risk_i \\ &+ \delta_5 Age_{it} + \delta_6 Age_{it}^2 + \delta_7 Year_{it} + w_{it} \end{aligned} \tag{2.10}$$

2.4.4 Variables in the two frontier equations

Tobin's Q: Tobin's Q is calculated as the ratio of market value of assets to the book value of assets. Market value is estimated as book value of total assets minus book value of equity plus market capitalisation and book value of total assets is simply value of total assets (Smith and Watts, 1992, Whited, 1992, Barclay and Smith Jr, 1995, Rajan and Zingales, 1995, Julio and Yook, 2012). For the profit frontier, this is included as an explanatory variable because a firm with better investment growth opportunity may have high profitability as well.

Size: Firm size is an important determinant of firm value or profit and the expected relationship between them is positive. Firm size is measured by natural logarithm of sales and square of size is also included to capture possible non-linearities in the relationship following Himmelberg et al. (1999) and Habib and Ljungqvist (2005). Large firms are expected to employ better technology and skilled workers and can easily insulate themselves from adverse external or internal shocks. However, the diminishing nature of the relationship between size and firm value (Demsetz and Villalonga, 2001) can also be captured by this variable, as each additional unit of capital employed may have a lower productivity than the previous one and so the average Q may fall as firms grow larger (Habib and Ljungqvist, 2005).

Leverage: Long-term debt scaled by total assets proxies for firm leverage which is included in this chapter as a control variable in order to capture the effects of capital structure on the market value and profit of the firm. The expected sign is indeterminate because on one hand, higher levels of debt in the capital structure acts as a disciplinary control of managerial behavior. This discipline involves reducing sub-optimal investments in order to service debt (Jensen, 1986). In addition, to retain control of the firm by preventing from liquidation and to avoid personal losses, managers will be motivated to give their best effort and generate cash flows to meet the fixed interest obligation associated with debt (Grossman and Hart, 1982, Thompson et al., 1992). On the other hand, high levels of leverage reduce the market value of the firm because high leverage increases equity holders financial risk because of the fixed interest obligation associated with debt. Moreover, it also increases the likelihood of liquidation and the expected future costs of liquidation are reflected in the current market value of the firm (Myers and Majluf, 1984).

Capital expenditure: Capital expenditure (CAPEX) includes additions to property, plant and equipment and is a measure of investment opportunities. Scaled by total assets, it is included in the empirical model in order to determine whether it adds to the value of the firms (Morgado and Pindado, 2003). Equity holders will assess whether such investments will lead to a particular firm's success and the present value of such future success will be reflected in the contemporaneous market value or profit of the firm. The expected relationship between investment opportunity and firm value is positive (Habib and Ljungqvist, 2005, Nguyen and Swanson, 2009) which indicates that equity holders value the investments that arise from such expenditures. If equity holders believe that firm's investments will yield a negative net present value, then a negative sign on the coefficient estimate for capital expenditure will be obtained.

Intangible asset: Past studies use research and development (R&D) and advertising as proxy for growth opportunity. It is generally expected that companies with substantial intangible investment opportunities will tend to adopt faster and better technology, be better managed and thereby will be value or profit enhancing. On the other hand the intangible assets are more discretionary and less easily monitored which may ease the way to suboptimal utilization of these intangible assets and may lead to a negative effect on market value or profit as well. In this study, intangible investment opportunity is measured by the ratio of intangible assets to total assets which is also considered as an indicator of future growth opportunities (Titman and Wessels, 1988, Michaelas et al., 1999, Ozkan, 2001).[8]

Tangibility: The ratio of property, plant, and equipment or total tangible assets to total assets and it's square are used to measure the degree of capital intensity or tangibility of the firm. Firms with more fixed assets should be worth more because such firms may face less agency cost related problems, as capital providers can observe, monitor and assess spending on tangibles easily (Habib and Ljungqvist, 2005). On the other hand, more dependence on fixed assets also incurs higher operating leverage and reduces firm value (Nguyen and Swanson, 2009). Therefore, the relationship is ambiguous.

Dividend: According to the traditional dividend policy views, Arnott and Asness (2003) find that higher dividends result in higher earnings growth. High

[8]As we have lots of missing values in the intangible asset variable, we create a dummy variable that equals 1 when data are missing, and 0 otherwise to avoid loss of firm-years. Himmelberg et al. (1999) and Habib and Ljungqvist (2005) both deal with missing data in similar fashion.

dividend payments restrict managerial discretion in spending company resources (Farinha, 2003, Khan, 2006) and tend to increase firm value. The ratio of total cash dividends to total assets is used here to proxy for earnings growth.

Firm risk: Firms are uncertain about a wide range of factors, including taxes, regulations, interest rates, wages, exchange rates, and technological change all of which may affect firm value or profit. Firm risk has been measured by the standard deviation of annual earnings before taxes by Castanias (1983) and MacKie-Mason (1990). In a similar way, we use standard deviation of earnings before interest, tax and depreciation (EBITD). The expected sign of firm risk on value or profit is indeterminate. Firm risk may work as a disciplinary device to tame the discretionary behavior of the managers. On the other hand, riskier firms may sometimes be poorly managed and are prone to various shocks.

Profit margin: Free cash flow, as measured by the ratio of operating profits or earnings before interest, tax and depreciation to total assets, is considered as a proxy for firm profitability (Palia, 2001, Nguyen and Swanson, 2009, Titman and Wessels, 1988, Whited, 1992). Firms with a large profit margin are expected to have high market value.

2.4.5 Variables in the inefficiency equation

As Battese and Coelli (1995) suggested, the explanatory variables in the inefficiency model may include some input variables in the stochastic frontier, provided the inefficiency effects are stochastic or the null hypothesis of $\gamma = 0$ is rejected. This implies that the inefficiency effects are significant and related to the chosen explanatory variables. On the contrary, if all elements of the δ vector are equal to zero, then the predicted inefficiency effects are not related to the explanatory variables in the Z vector and so the half-normal distribution originally specified in Aigner et al. (1977) is obtained. As regards to the explanatory variables, Margaritis and Psillaki (2007) assume that leverage, risk, size, growth opportunities, market power and exposure to international trade are likely to influence firm efficiency. Berger and Bonaccorsi di Patti (2006) also use leverage, firm size, variance of earnings as firm risk along with regulatory environment, ownership structure and market concentration as control variables for efficiency. Both of the above studies estimated efficiency index first and estimated separate regression of the estimated efficiency on various explanatory variables. In this study, the following variables are included in the Z vector. The choice of variables are quite different from Habib and Ljungqvist (2005) and Pawlina and Renneboog (2005) due to data unavailability.

Size: The effect of size on inefficiency is likely to be negative as larger firms are expected to use better technology, be more diversified, better managed and better organized. Square of size is also included for similar reasons as in the frontier equations.

Leverage: According to the agency cost of outside equity hypothesis, the effect of leverage on inefficiency should be negative. This is because debt financing along with other external financing can induce monitoring by lenders (Agrawal and Knoeber, 1996). Second, debt may directly reduce agency costs by reducing free cash flow available for expropriation or for investment in risky and negative net present value projects (Jensen, 1986, Myers, 1977). Third, compared to the alternative of issuing new equity, the issue of debt increases the manager's equity holding as a proportion of equity financing which enhances alignment of interests further. In contrast to these, the opposite relationship between leverage and inefficiency may arise from conflicts between debt holders and shareholders. If the shareholders find the risk of financial distress too high, they may opt to shift risk to the debtholders or become reluctant to control risk cushioned by their limited liability advantage and may even deteriorate the financial distress of the firm and give rise to the agency cost of outside debt (Jensen and Meckling, 1976).

Firm risk: The effect of this variable on firm inefficiency is expected to be positive as riskier firms tend to be those which are poorly organized and may be less efficient (Berger and Bonaccorsi di Patti, 2006).

Age: It is not unlikely that the length of operation and active presence in the market can be related to a firm's efficiency. Due to the effects of learning curve and survival bias, older firms are likely to be more efficient than younger or the start-up firms (Ang et al., 2000). However, Battese and Coelli (1995) finds that the older firms are more inefficient than the younger ones. Many researchers use date of incorporation to calculate firm age. We are using the date a company or security was added to the Worldscope database. This can be a good enough proxy for firm age as it is very likely that a company will start appearing in the database soon after they are incorporated with any stock exchange. Almeida and Campello (2007) follow the same approach and use number of years a firm appears in their chosen database as a proxy for firm age.

Year: Year variable in the inefficiency equation accounts for the possibility that the inefficiency effects may change linearly with respect to time. The distributional assumptions of the Battese and Coelli (1995) model on the inefficiency effects allow to identify the time-varying behavior of the inefficiency effects in addition to the intercept parameter δ_0.

2.5 Data and descriptive statistics

We use the data collected from the Worldscope Global Database. We have an unbalanced panel of 1122 firms from thirty three different sectors from 1981 to 2009 with a minimum of three to a maximum of twenty nine consecutive years of observations and a total of 13183 firm-years. These thirty three sectors are differentiated according to FTSE/Dow Jones Industrial Classification Benchmark (ICB) codes. All financial variables are deflated with GDP deflator and all regression variables are winsored at the 1% and 99% level to get rid of the extreme outliers. Table 2.1 reports means and distributional information for all the regression variables used in this chapter.

Firm size is captured by natural logarithm of sales, mean of which is 10.92 and this gives an impression that average firm size is reasonably big. However,

Table 2.1: Descriptive Statistics

This table gives mean and distributional information for all the regression variables for which data is collected from the Worldscope Global Database for 1122 UK firms listed on the London Stock Exchange over the period 1981 to 2009. All financial variables are deflated with GDP deflator and all regression variables are winsored at the 1% and 99% level to get rid of the extreme outliers. Tobin's Q is calculated as the ratio of market value of assets to the book value of assets. Market value is estimated as book value of total assets minus book value of equity plus market capitalization and book value of total asset is simply value of total assets. Natural logarithm of total sales and natural logarithm of the number of years a firm appears in the database are used as proxies for firm size and firm age respectively. Leverage is calculated as ratio of long term debt to total assets; capital expenditure as ratio of capital expenditure or additions to fixed assets to total assets; intangible asset as ratio of intangible assets to total assets, tangibility as ratio of total tangible assets to total assets; dividend payout as ratio of total cash dividend paid to total assets; profit margin as ratio of operating profits or earnings before interest, tax and depreciation to total assets. Standard deviation of profit margin is used as a proxy for firm specific risk.

	Mean	SD	Min	Q1	Median	Q3	Max
Market value	11.83	2.230	7.693	10.13	11.59	13.30	17.64
Size	10.92	3.243	4.301	9.448	11.28	12.97	16.74
Age	2.114	0.862	0	1.609	2.303	2.833	3.367
Leverage	.1043	.1352	0	.0003	.0524	.1596	.6539
Capital expenditure	.0584	.0610	0	.0175	.0405	.0757	.3306
Intangible asset	.1406	.2120	0	0	.0131	.2198	.8148
Tangibility	.2900	.2386	.0021	.0873	.2453	.4253	.9220
Dividend	.0207	.0240	0	0	.0157	.0312	.1312
Firm risk	.1354	.1449	.0028	.0469	.0808	.1530	.6598
Profit margin	.0527	.2766	-1.520	.0357	.1180	.1813	.4325
Tobin's Q	2.033	1.864	.5193	1.072	1.464	2.178	12.69
Asset base	11.35	2.280	6.722	9.681	11.14	12.82	17.07

the standard deviation of firm size is 3.243 which hints on the diversity of firm size in the sample. An average firm in the sample has Tobin's Q of 2.033 and the maximum is 12.69. An average firm is highly capital intensive, with median investment in tangible assets is 24.53% of total assets, a bit lower than the mean of 29%. The leverage of an average firm is 10.43% which is almost exactly twice of the median value. The sample contains unlevered firms as well as highly levered firms with a maximum 65.39% of leverage. There are firms with a negative profit margin, but mean and median are both positive at 5.27% and 11.80% respectively. The average rate of capital formation is 5.84%, the median of which is 4.05%. The risk is measured as the standard deviation of the operating profit margin of each of the firms over their respective panel years. This measure of risk is thus working as a static variable with a mean of 13.54%. This is driven up by the quartile of largest firms and thus may not be representative of the average firm risk. The median firm risk of 8.08% rather gives a better representation. The dividend payment with respect to total assets by an average firm is 2.07%, which seems quite low. Intangible investment opportunity of an average firm is 14.06%, but again this is not representative of the sample as the twenty fifth percentile has a value of zero and the last percentile has a value of 81.48%.

2.6 Empirical results

2.6.1 Market value frontier

In case of the market value frontier, the result of which is shown in panel A of table 2.2, most of the variables have the expected signs. In model 1, we have only controlled for the variables as in Himmelberg et al. (1999). Model 2 is our final one where we extend the set of explanatory variables and we explain the results of this model only. The frontiers are estimated with sector and year dummies and also a missing dummy variable for the intangible asset. Market value of the firm changes negatively with firm size but positively with the square firm size with a turning point at 12.39, slightly less than the 75th percentile value. The initial negative relationship up to the turning point may be due to the diminishing returns after controlling for firms' asset base. It should be noted here that, multicollinearity tests between asset base and firm size did not expose any potential problems. The overall U shaped relationship gives an impression that the market does not react positively to initial growth in sales, but relies on firms with a substantially higher level of sales or with persistently positive growth rate, which is quite logical considering that here the firm is relying on long run value maximizing motive.

Similarly, tangibility or capital intensity shows a negative effect but square of them have the opposite effect on firm value. The turning point of tangibility is 1.75, which is outside the range of the sample. As described earlier, the average

Table 2.2: Market value frontier

Following the technique proposed by Battese and Coelli (1995), maximum likelihood method is used for simultaneous estimation of the parameters of the stochastic frontiers and the models for the inefficiency effects. Here, frontiers are estimated based on market value maximization approach and efficiencies predicted from these market value frontiers are termed as long run efficiencies. The frontiers have been estimated with sector and year dummies and also a missing dummy variable for the intangible asset.

A: Frontier	Model 1			Model 2		
	coeff	std.er	t-ratio	coeff	std.er	t-ratio
Size	-0.548	0.020	-27.23	-0.570	0.018	-31.83
Size^2	0.024	0.001	29.34	0.023	0.001	30.09
Leverage				0.348	0.045	7.789
Capital expenditure	2.375	0.090	26.26	2.273	0.089	25.64
Intangible asset	-0.497	0.029	-17.25	-0.454	0.029	-15.80
Tangibility	-0.930	0.077	-12.07	-1.096	0.074	-14.76
Tangibility^2	0.115	0.086	1.331	0.312	0.083	3.746
Dividend				0.065	0.002	32.07
Firm risk				0.710	0.070	10.21
Profit margin	0.201	0.022	9.343	0.096	0.023	4.236
Asset base	0.917	0.007	127.5	0.944	0.007	141.4
Constant	4.389	0.147	29.81	4.294	0.138	31.22
B: Inefficiency						
Size	-0.347	0.021	-16.35	-0.380	0.022	-17.17
Size^2	-0.003	0.001	-2.614	-0.003	0.001	-2.714
Leverage	-1.539	0.196	-7.847	-0.714	0.193	-3.694
Firm risk	-1.291	0.112	-11.54	0.007	0.166	0.045
Age	-0.019	0.131	-0.147	-0.088	0.132	-0.671
Age^2	0.061	0.027	2.258	0.080	0.025	3.229
Year	0.054	0.006	9.879	0.053	0.006	9.104
Constant	1.886	0.271	6.962	1.873	0.274	6.824

firm in the sample is highly capital intensive and such dependence on fixed assets brings with it higher operating leverage or higher business risk which creates a negative impact among the risk averse investors. Both Habib and Ljungqvist (2005) and Nguyen and Swanson (2009) find such negative effects in their studies. Leverage is positively affecting the firm value because a rise of debt in the capital structure reins the discretionary managerial behavior and managers will be prompt to generate cash flows for servicing the debt to avoid liquidation which will drive up the value of the firm. Capital expenditure, dividend, risk and profit margin all have positive effects on firm value. So, the equity holders assess additions to fixed capital, higher dividend payment, firm risk caused by any of the diverse factors and profit margin as the outcome of firms' success or key to further growth and such prospects boost up the market value of the firm. The impact of intangible investment is negative on firm value and this can be related to the suboptimal and discretionary expenditure on intangibles which the shareholders may feel redundant.

The model also involves the specification of a regression model for the predicted mean inefficiency effects, the result of which is given in panel B of table 2.2. The predicted inefficiency is changing negatively with firm size and leverage. So, the general conception that larger firms are more efficient remains valid in this case. Larger firms benefit from better corporate governance, possess skilled and proficient workers, have closer tie with the legal and financial institutions, are more diversified and all these lead to better management and higher efficiency. Also the inverse relationship between inefficiency and leverage supports the agency cost of outside equity hypothesis which predicts that higher leverage puts more pressure on managers to maximize value, and thus mitigates agency problems between the shareholders and managers. Inefficiency decreases negatively with firm age initially which is expected, even though it is insignificant before it starts to increase significantly with age. This may be due to the speed of adjustment as very old firms may not be quick enough in reacting to news about future investment opportunities (Tobin's Q), possibly due to their different production technologies or because they suffer more from bureaucracy and divisional hierarchies (Gilchrist and Himmelberg, 1995). The level of inefficiency is also found to increase over time.

The value for the γ parameter is reported in table 2.2.a, which shows that 73% of total error variance is caused by the one sided inefficiency term or deviations from the frontier are characterized more so by inefficiency or agency costs rather than white noise and this is statistically significant as well. The null hypothesis of γ equals zero is rejected and this indicates that the inefficiency effects are stochastic and the SFA specification leads to a likelihood gain. The LR test also supports this by rejecting the null hypothesis that the inefficiency effects are absent and unrelated to the chosen explanatory variables.

Table 2.2.a: Diagnostics for Market value frontier

This table gives the diagnostics tests for our market value frontiers. Here, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$. LR test statistics are reported for the likelihood ratio test for the null hypothesis of $\gamma = \delta_0 = \delta_1 \cdots = \delta_7 = 0$. The degrees of freedom of this test statistic is 9 which has a critical value of 20.97 at the 1% level of significance.

	Model 1			Model 2		
	coeff	std.er	t-ratio	coeff	std.er	t-ratio
σ^2	0.552	0.012	46.47	0.588	0.014	42.22
γ	0.663	0.011	58.26	0.734	0.010	73.66
No of firms			1122			1122
No of observations			13183			13183
Log likelihood value			-9592.24			-8997.12
LR test statistics of the one sided error			1041.69			1119.40

Table 2.2.b: Market value efficiency

This table gives mean and distributional information for our predicted market value efficiencies (MVE) from model 1 and 2.

	Mean	SD	Skewness	Min	Q1	Median	Q3	Max
MVE_{Model1}	0.752	0.193	-2.087	0.007	0.704	0.822	0.877	1
MVE_{Model2}	0.745	0.201	-2.005	0.006	0.696	0.821	0.876	1

The mean efficiency predicted from the second market value frontier model is 74.5% which means that an average firm has market value 25.5% below it's best performing peer or an average firm fails to maximize value due to agency conflict. The statistical and distributional information of the efficiency term is presented in table 2.2.b. Although the mean of the predicted efficiency is almost 10 percentage point lower than that estimated by Pawlina and Renneboog (2005) who considered period 1992-1998 only, our mean predicted efficiency turns to 80% over that period.

2.6.2 Profit frontier

In the second frontier where the dependent variable is operating profit which the firms are expected to maximize, the results presented in panel A of table 2.3 are not quite similar to that of the market value frontier. Keeping similarity with market value frontier, here as well model 1 includes variables suggested by Himmelberg et al. (1999) only and model 2 is the extended one. Here, the relationship between profit margin and firm size is inverted U shaped in contrast with the U shaped relationship in the market value frontier. Similarly the contrasting inverted U shaped relationship is present between profit margin and tangibility as well. However, capital expenditure, dividend, and risk are still affecting the operating profit positively and so is Tobin's Q. Profit margin is found to have the same negative relationship with intangible investment, but the negative relationship between leverage and profit margin is again a disparity.

So, the profit frontier differs from the earlier market value frontier in terms of firm size, tangibility and leverage. The operating profit responds positively with firm size and tangibility initially, but the relationship turns the other way after firm size of 12.50 and tangibility of 0.37. Here the managers are perhaps inclined to raise the profit at any cost to create a positive impression among the owner shareholders about their work effort or competence desiring to capture a better compensation package for them. This short sighted strategy may raise the agents benefit and even inflate the principle's financial position for the time being, but most unlikely be sustainable for the company. This can be the reason behind the inverted U shaped relationship between profit margin and firm size. Capital intensity and it's related operating leverage was adversely affecting the market value earlier, but here initially the negative effect is compensated more by the positives of investment in tangible assets on firm's operation before inverting again. The negative relation of intangible investment opportunity and leverage with profit margin is again perhaps due to the agent's short sighted growth motive due to which they might not feel the urge to reduce sub-optimal investments, take excess leverage and pay higher repayment for that and these push the profit down.

Table 2.3: Profit frontier

Following the technique proposed by Battese and Coelli (1995), maximum likelihood method is used for simultaneous estimation of the parameters of the stochastic frontiers and the models for the inefficiency effects. Here, frontiers are estimated based on profit maximization approach and efficiencies predicted from these profit frontiers are termed as short run efficiencies. The frontiers have been estimated with sector and year dummies and also a missing dummy variable for the intangible asset.

A: Frontier	Model 1			Model 2		
	coeff	std.er	t-ratio	coeff	std.er	t-ratio
Size	0.027	0.002	13.14	0.025	0.002	11.58
Size^2	-0.001	0.0001	-15.44	-0.001	0.0001	-13.89
Leverage				-0.015	0.007	-2.017
Capital expenditure	0.386	0.021	18.28	0.386	0.017	22.19
Intangible asset	-0.055	0.007	-8.543	-0.043	0.006	-7.196
Tangibility	0.099	0.016	6.083	0.064	0.014	4.485
Tangibility^2	-0.140	0.018	-8.007	-0.087	0.015	-5.666
Dividend				0.015	0.0004	33.50
Firm risk				0.249	0.011	21.93
Tobin's Q	0.040	0.001	49.35	0.025	0.001	32.28
Constant	0.001	0.015	0.069	-0.002	0.015	-0.133
B: Inefficiency						
Size	0.076	0.004	21.94	0.081	0.004	20.95
Size^2	-0.015	0.0002	-79.38	-0.014	0.0002	-73.73
Leverage	0.387	0.032	12.24	0.275	0.030	9.116
Firm risk	2.544	0.068	37.55	2.759	0.043	64.14
Age	-0.188	0.032	-5.860	-0.234	0.031	-7.570
Age^2	-0.005	0.006	-0.822	0.016	0.006	2.707
Year	0.003	0.001	2.817	0.004	0.001	4.258
Constant	-0.097	0.069	-1.410	-0.219	0.050	-4.363

Turning to the regression on inefficiency presented in panel B of table 2.3, profit inefficiency is found to be negatively related to firm size and increasing over time, similar to that of market value inefficiency. However, the results differ in case of leverage. Even though the positive effect of leverage on profit inefficiency contradicts with the earlier findings, but it is in line with the managerial short run growth perspective. Excess leverage brings with it the risk of bankruptcy and financial distress. These may prompt the limited liability shareholders or their managers to engage in deleterious activities and thus raise the agency cost of outside debt. Profit inefficiency remains negatively related with age throughout the whole sample.

Table 2.3.a reports the diagnostics test according to which the null hypothesis of $\gamma = 0$ and inefficiency effect is absent are rejected in this case as well. The estimate for the variance parameter, γ, is close to one (0.990), which indicates that the inefficiency effects are likely to be highly significant in this analysis as well and are clearly stochastic. Also they are significantly related to the chosen explanatory variables as suggested by the LR test. In this case, the predicted mean efficiency is 86.6%, detail information of which is given in table 2.3.b.

Table 2.3.a: Diagnostics for Profit frontier

This table gives the diagnostics tests for our profit frontiers. Here, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$. LR test statistics are reported for the likelihood ratio test for the null hypothesis of $\gamma = \delta_0 = \delta_1 \cdot \cdots = \delta_7 = 0$. The degrees of freedom of this test statistic is 9 which has a critical value of 20.97 at the 1% level of significance.

	Model 1			Model 2		
	coeff	std.er	t-ratio	coeff	std.er	t-ratio
σ^2	0.196	0.005	39.90	0.167	0.003	58.52
γ	0.988	0.001	2064.80	0.990	0.0004	2726.99
No of firms			1122			1122
No of observations			13183			13183
Log likelihood value			9540.31			10512.23
LR test statistics of the one sided error			17747.24			16642.35

Table 2.3.b: Profit efficiency

This table gives mean and distributional information for our predicted profit efficiencies (PE) from model 1 and 2.

	Mean	SD	Skewness	Min	Q1	Median	Q3	Max
PE_{Model1}	0.863	0.162	-2.438	0.099	0.853	0.928	0.955	1
PE_{Model2}	0.866	0.163	-2.426	0.099	0.853	0.933	0.960	1

2.6.3 Comparison between short run and long run efficiency

In this study, two different frontiers are estimated aiming to capture the dynamism in the inefficiency or agency conflicts. And the results suggest that long run or market value efficiency is consistently (in 11537 out of the 13183 firm years or 87.5% cases) smaller than the short run or profit efficiency. As shown in table 2.4, the sign test rejects the null hypothesis that the median of the difference between the two measure of efficiency is zero. The signed-rank test rejects the null hypothesis that both of their distributions are the same, which is also supported by the kernel density graphs in figure 2.1.

Table 2.4: Tests of the difference between profit and market value efficiency

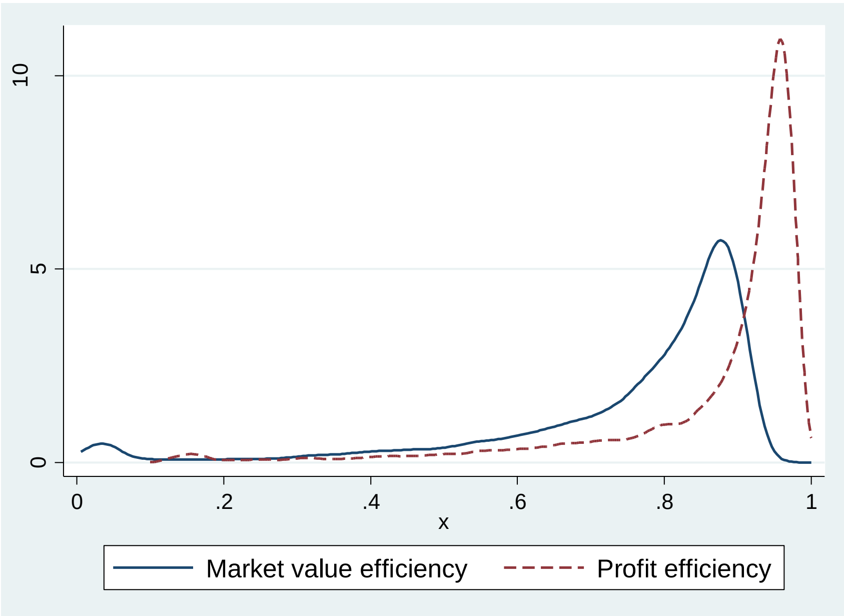
Sign test rejects the null hypothesis that the median of the differences between profit and market value efficiency is zero and signed-rank test rejects the null hypothesis that both of their distributions are the same. Here, the difference between profit efficiency (Pr.eff) and market value efficiency (Mv.eff) are positive for 11537 observations out of total 13183 and negative for the remaining 1646.

Sign test	Wilcoxon signed-rank test
One-sided tests:	
Ho : median of Pr.eff - Mv.eff = 0	Ho: Pr.eff = Mv.eff
Ha : median of Pr.eff - Mv.eff > 0	Ha: Pr.eff $\neq$ Mv.eff
Pr(# positive $\geq$ 11537)= 0.000	z= 74.726
Ho : median of Pr.eff - Mv.eff = 0	Prob $>\mid z \mid$ =0.000
Ha : median of Pr.eff - Mv.eff < 0	
Pr(# negative $\geq$1646)= 1.000	
Two sided tests:	
Ho : median of Pr.eff - Mv.eff = 0	
Ha : median of Pr.eff - Mv.eff $\neq$ 0	
Pr(# positive $\geq$ 11537 or # negative $\geq$ 11537) = 0.000	

From the firm owner's perspective, profit maximization should not be the only objective; it should be coupled with capturing more market share, maintaining a stable earnings growth, insulating from financial crunch, diversifying operation, etc. So, even though profit maximization facilitates wealth creation, but when the managers give priority to value creation by shifting their focus to an array of objectives, it may not be possible for them to maintain a stable and high level of operational or managerial effectiveness, which might otherwise be possible and hence overall efficiency may fall down at the expense of longer term broader outlook.

Figure 2.1: Kernel density of profit and market value efficiency

The kernel density estimations of both the predicted profit and market value efficiencies confirm the variation in their distributions.



Spearman correlation between the two predicted efficiency is also calculated and the null hypothesis that the two are independent is rejected and the correlation coefficient between the two is found to be .5108. Even though the two efficiencies are predicted from different maximization objectives, but it is revealed by the joint maximum likelihood estimation that 73% of the deviations from the market value frontier and 99% of the deviations from the profit frontier are characterized by inefficiency or agency costs. In other words, the predicted inefficiencies are highly significant and related to the different firm specific variables. So, even though maximizing accounting profit and maximizing shareholder value are not identical, it seems reasonable that the correlation between them is positive. And this can also be supported by the fact that profit maximization is a subset of wealth maximization and no matter whether the firm managers are driven by short run or long run horizon, inherent inefficiencies or agency conflict to a certain extent are always there in an average firm.

2.6.4 Variation in efficiency with firm size

In the case of both the market value frontier and profit frontier, the predicted inefficiencies are found to be significantly decreasing with firm size. So, larger firms tend to show better efficiency, both from the short run and long run point of view. To check the distributional characteristics of the predicted efficiencies by firm size, the firms are partitioned into small, small medium, medium large and large on the basis of average sales (in natural logarithm form which we have used as a proxy for firm size) over their respective panel years. The firm year observations are also partitioned similarly on the basis of their appearance on different parts of the sales distribution. The predicted efficiencies from the two frontier equations (2.8 and 2.9) covering the whole sample are then sorted first into these four quartiles of firms and then into four quartiles of firm year observations separately. For a robustness check, firms are also partitioned in the same way on the basis of total assets as well so that any variability between input and output based sorting is revealed, if there is any.

Table 2.5 and 2.6 confirm that performance shortfall is present among firms of all sizes, but decreasing monotonically with firm size. These results are expected and in line with the explanations given earlier that larger firms are likely to enjoy better corporate governance structures, have closer tie with the legal and financial institutions which are likely to put more restrictive covenants on the operational and financial activities of the firm and monitor managerial activities closely, are more diversified both in terms of their production and financing choices and vertically integrated. All these factors are expected to alleviate the conflicts of interest among the stakeholders (Hoshi et al., 1991) and can lead to better management and higher efficiency. Lack of further investigations may raise some questions on the magnitude of this effect in both the tables, for panel A in

Table 2.5: Efficiency among four size groups (sorted by total sales)

The firms and the firm year observations are partitioned separately into small, small medium, medium large and large in panel A and panel B respectively using sales as a measure of firm size. The predicted efficiencies from the two frontier equations covering the whole sample are then sorted into these four quartiles.

		Market value efficiency (mean)	Profit efficiency (mean)
A:	No of firms		
Small	281	.3999	.6385
Small medium	280	.6716	.8206
Medium large	281	.7924	.9076
Large	280	.8702	.9389
B:	No of obs.		
Small	3296	.5122	.7100
Small medium	3295	.7537	.8866
Medium large	3297	.8344	.9251
Large	3295	.8815	.9437

particular where we use time invariant size classification. It can be enquired that facing such possibility of increasing their efficiency significantly, the small firms may have a keen incentive to merge with their larger counterparts. But, it may be argued in response that, a prospective merger between a very small inefficient firm with a very large efficient one, may not necessarily be as advantageous for the large firm as it could be for the small one. And also, the magnitude of size effect on efficiency is relatively less pronounced in panel B of both the tables, where we allow the firm year observations to switch between sizes and the latter way of classification may be more appropriate for considering the evolution of firms over time. It could be interesting to include some firm specific variables as a proxy for monitoring and incentives in the inefficiency equation following Habib and Ljungqvist (2005) and Pawlina and Renneboog (2005) to investigate the reasons for this positive monotonic relationship between firm size and efficiency. But, unfortunately we could not get data for ownership structure for our sample firms and capital and product market regulatory factors from the chosen database. This can be a good avenue for future research.

As it was revealed in the estimation of inefficiency equations that both the short and long run inefficiencies were increasing over time, average efficiency of

Table 2.6: Efficiency among four size groups (sorted by total assets)

The firms and the firm year observations are partitioned separately into small, small medium, medium large and large in panel A and panel B respectively using total assets as a measure of firm size. The predicted efficiencies from the two frontier equations covering the whole sample are then sorted into these four quartiles.

		Market value efficiency (mean)	Profit efficiency (mean)
A:	No of firms		
Small	281	.5288	.6820
Small medium	280	.6439	.8328
Medium large	281	.7809	.9007
Large	280	.8707	.9388
B:	No of obs.		
Small	3296	.5650	.7304
Small medium	3296	.7152	.8779
Medium large	3295	.8215	.9146
Large	3296	.8802	.9424

all firms by year from 1981 to 2009 is calculated and average efficiency of the sample firms are found to be significantly decreasing from 89% in 1981 to 68% in 2009 in case of market value efficiency and moderately decreasing from 95% to 83% in case of profit efficiency. The comparison of mean predicted short and long run efficiency among each of the thirty three sectors also demonstrate high short run efficiency among each of the sectors, and deviation is smallest in the fixed line telecommunication sector and highest in the mining sector.

2.7 Conclusion

Although agency-theoretic models are usually formulated in terms of value rather than profit maximization, in this study both of the methods have been utilized considering that shortfall of firms' actual value from their potential due to agency costs can be proportional to the similar shortfall in their accounting profits or the other way round. Estimations of the two stochastic frontier models give quite interesting results and are in line with the theories and previous studies on agency cost as well. In this study, employing Battese and Coelli (1995) model, long run corporate efficiency is predicted from the modern approach focusing on wealth or value maximization and the short run corporate efficiency is predicted from the traditional approach focusing on earning maximum profit as inverse proxies of total agency cost to bring in the dynamics of the principle agent conflict. It is revealed in the estimation that, an average firm in the sample achieves 74.5% of it's best-performing peer's market value or market value of an average firm falls 25.5% below it's best performing peer. On the other hand, profit margin of an average firm falls 13.4% below it's best performing peer. Both the predicted inefficiency effects are found to be highly significant in the analysis. The inefficiency effects are clearly stochastic and significantly related to the chosen explanatory variables as well. Market value inefficiency decreases with leverage supporting the agency cost of outside equity hypothesis. On the contrary, profit inefficiency increases with leverage following the agency cost of outside debt hypothesis possibly due to the agent's short sighted growth motive. Both the short run and long run efficiency (inefficiency) increases (decreases) with firm size and decreases (increases) over time. The profit efficiency is found to be consistently higher than the market value efficiency and there is a positive rank correlation between them which confirms that an average firm in the UK suffers from inefficiency or agency conflict to a certain extent, no matter whether the firm managers are driven by short run or long run growth perspective.

Chapter 3
Corporate Efficiency, Credit Status and Investment

3.1 Introduction

Chapter one illustrates in detail how informational asymmetries and related problems (imperfect information about the quality or riskiness of the borrowers' investment projects, incentive problems and costly monitoring of managerial actions) lead to an imperfect substitutability between external and internal funds and makes the Modigliani and Miller (1958) irrelevance theorem invalid. Fazzari et al. (1988), Bond and Meghir (1994) investigate the reasons why the level of corporate investments of the financially constrained firms are most sensitive to the availability of internal funds. However, Kaplan and Zingales (1997) and Cleary (1999) find empirical evidence that while investment levels do depend significantly positively on internal cash flows, the least financially constrained firms are most influenced by the availability of internal funds. A vast number of literatures follow this debate and the controversy is yet to be resolved.

For more than two decades, the debate over the role of internal finance (mostly proxied by cash flow) in an investment equation has been hovering mainly on two crucial points. The first of them stems from the difficulty in controlling for the investment opportunities of a firm. The standard is to use Tobin's Q, but again finding a convincing proxy for the unobservable marginal Q is a problem. Most studies use average Q under the assumption of constant returns to scale and perfectly competitive product and factor markets following Hayashi (1982) and adding cash flow to the model, they interpret residual sensitivity of investment to cash flow as evidence of financing constraints (Fazzari et al., 1988, Oliner and Rudebusch, 1992, Devereux and Schiantarelli, 1990, Hoshi et al., 1991, Schaller, 1993, Audretsch and Elston, 2002, Bond et al., 2003, Chirinko and Schaller, 1996). On the contrary, Gilchrist and Himmelberg (1995), Erickson and Whited (2000, 2002), Cummins et al. (2006) show that because of difficulty in measuring marginal investment opportunities, cash flow may also convey information about investment opportunities which is not reflected in the estimated Q. In such cases, the observed cross-sectional variations in investment-cash flow sensitivity may simply be due to variations in Q measurement error and fails to provide convincing proof for the existence of capital market imperfections. Moreover, the firms facing severer information asymmetry related problems are likely to be more severely affected by the measurement problem in Q as that incorporates firm market value. These firms are also the ones which are most likely to be financially constrained and if they are a priori classified as such, higher estimated coefficients of cash flow in investment regressions is expected for them.

Such prior classification of firms into constrained and unconstrained groups is the other crucial point behind the controversial investment cash flow sensitivity issue. Following Fazzari et al. (1988), many subsequent studies have classified firms a priori as financially constrained on the basis of a single and in some cases two quantitative or qualitative indicators and the predictive power of cash flow is shown much higher for such firms. This cross-sectional difference in the sensitivity of investment to cash flow is a major theoretical prediction of capital market imperfections. For example, Bond and Meghir (1994) use dividend payout ratio, Devereux and Schiantarelli (1990), Oliner and Rudebusch (1992) use size, age and pattern of insider trading, Gertler and Gilchrist (1994) use size only, Hoshi et al. (1991) use degree of bank affiliation, Whited (1992) use bond rating, Schaller (1993) use degree of shareholding concentration etc. The major concern in this technique is the endogenous selection problem as the classification criteria can be correlated with the level of investment or with the firm-specific and time invariant component of the error term and also with the idiosyncratic component (Hausman and Wise, 1977). The estimation results thus can be highly sensitive to the classification criteria and threshold value chosen for sample split and all these are likely to cause static misclassification. There are potential problems of dynamic misspecification as well as the exogenously classified firms are kept in the same regime over the whole sample period. During the sample period it may be the case that a firm that is initially faced with severe financing constraints becomes less financially constrained later and vice versa. This will especially be the case when the extent of capital market imperfections depends on general macroeconomic environment and becomes more important when the time period under consideration lengthens. Hence, although it is possible to identify firms that may be financially constrained, it is quite often impossible to identify the years during which they remain constrained. This makes it almost impossible to differentiate between firm-specific effects on investment and the effects of financing constraints (Kaplan and Zingales, 1997).

The problems associated with Tobin's Q may also be systematically related to the criteria used to identify financially constrained firms. Gilchrist and Himmelberg (1995) note three such cases. First, the pre identified financially constrained firms are typically newer, smaller, and faster growing than other firms in the sample and the stock market is unlikely to have accumulated the usual stock of knowledge that arises through detailed evaluation and monitoring of firms over time. Thus, Tobin's Q might contain less information about investment opportunities for these firms, which can shift explanatory power away from Tobin's Q toward cash flow. Second, if newer, smaller, faster-growing firms are still learning about their fundamental value, then realizations of cash flow will presumably reveal relatively more information. If the information revealed by cash flow innovations is not adequately captured by Tobin's Q, then the investment decisions of such firms will be systematically more sensitive to cash flow fluctuations. Third, smaller, younger firms may react more quickly to news about future profit opportunities, possibly because they have different production technologies or because they are less encumbered by layers of bureaucracy and divisional hierarchies. If Tobin's Q is a poor proxy for investment opportunities, and cash flow enters purely as a fundamental, then firms with higher adjustment speeds will tend to have higher cash flow coefficients. All these reasons make such firms appear to be financially constrained when in fact they may not.

In order to tackle the various problems mentioned so far, some remedial measures have been suggested by previous literatures. One of them is to use interaction terms between cash flow and variables measuring the severity of market imperfections. This is based on the idea that investment-cash flow sensitivity should change with capital market imperfection if it is at all linked with these imperfections. Another is to assume a non-zero cash flow coefficient for unconstrained firms so that it can capture any residual part of future profitability which may not be fully controlled for. Assuming this, the cash flow coefficient of the constrained firms should still be higher than that of the unconstrained firms reflecting the effect of market imperfections. In this chapter, we attempt to combine and make use of both these remedial measures.

Firstly, we concentrate on the changing pattern of investment-cash flow sensitivities with a variable measuring the extent of such imperfection. For this, we use our two direct measures of firm efficiency as inverse proxies of agency costs from chapter two, namely market value efficiency and profit efficiency.[9] We anticipate that investment cash flow sensitivity will vary with our predicted corporate efficiencies. We further expect that the effect of efficiency on the cash flow sensitivities will be dissimilar between firms with different degrees of financial constraints. More importantly, efficiency can in fact affect the credit status of the firms as a financially constrained firm may become unconstrained with the improvement of it's efficiency. These arguments may establish a non monotonic effect of corporate efficiency on cash flow sensitivities.

Secondly, we try to endogenously classify firms according to their financial constraint status and allow switching between them to avoid the static and dynamic misclassification problems and in line with our prediction that corporate efficiency can simultaneously affect a firm's financial constraint status and investment cash flow sensitivity. In order to do that, an estimator which is capable of simultaneously incorporating the effects of efficiency on cash flow sensitivities and on the constraint status of the firms is needed. To estimate our investment regressions, we rely on an endogenous switching regression framework with unknown sample separation. Hu and Schiantarelli (1998), Hovakimian and Titman (2006), Almeida and Campello (2007) use such models in their attempt to address the problems in testing for financial constraints. This model allows simultaneous determination of firms' probability of facing constrained or unconstrained access to credit along with the variation in their investment behavior across groups.

[9]More detailed explanation and properties of these predicted efficiencies are given in page 53 and 56 of this thesis. Here, we will use the market value efficiency calculated from model 2 of table 2.2 (p. 51) and the profit efficiency calculated from model 2 of table 2.3 (p. 55) as those were our final models.

Hovakimian and Titman (2006) rely on cash from asset sales and Almeida and Campello (2007) rely on asset tangibility to interpret their results in addition to other standard variables used in Hu and Schiantarelli (1998). We include corporate efficiencies as an inverse proxy of agency cost along with asset tangibility and other standard variables used in the literature to differentiate investment behaviors of constrained and unconstrained firms in line with our hypothesis.

This chapter mainly contributes to the existing literature by introducing corporate efficiency in investment equation in another attempt to clarify the role of cash flow. Despite the existing concerns over the role of cash flow, we argue that investment-cash flow sensitivities can be used to gauge the effects of financing frictions on investment by trying to resolve the issue of possible biases arising from unobservable variation in investment opportunities. Further to this, the expected non monotonic effect of corporate efficiency on cash flow sensitivities will provide a different resolution to the highly debated Fazzari et al. (1988) and Kaplan and Zingales (1997) issues. Our attempt to establish a link between corporate efficiency and investment provides a distinctive complement to the existing literature by suggesting new ways to study the impact of financial constraints on firm behavior. Another interesting feature of this study is it's contribution to the debate with a focus on the UK rather than the US. To the best of our knowledge, a switching regression model has not been used in any of the UK studies involving financial constraints and investment.

Using an unbalanced panel data on 1122 UK firms listed on the London Stock Exchange during the period 1981 to 2009, we estimate a number of endogenous switching regression models incorporating our predicted corporate efficiencies from the stochastic frontier analysis in chapter two along with other variables used in contemporary literatures. We mainly rely on the market value efficiency considering it's relative advantage in better business evaluation. However, we also estimate the models with profit efficiency separately to check whether our propositions are robust to this alternative measure of corporate efficiency. Our different model specifications strive to confront the major challenges in examining the effects of capital-market imperfections on investment decisions of individual firms and will mainly concentrate on inspecting the following:

1. Whether and how efficiency is affecting the likelihood of being financially constrained or unconstrained

2. Whether investment-cash flow sensitivity is increasing or decreasing with efficiency

3. Whether the effect of efficiency on cash flow sensitivities is monotonic or non-monotonic

The rest of this chapter is structured into different sections as follows. Section 3.2 draws literature survey, section 3.3 describes the methodology, section 3.4 brings model specification and description of the variables, section 3.5 introduces data and descriptive statistics, section 3.6 presents the empirical results and analysis and finally section 3.7 concludes the chapter.

3.2 Literature review

The controversial role of cash flow in an investment equation remains the main focal point in many of the past and recent literatures on financial constraints and investment. Many subsequent studies following Fazzari et al. (1988) rely on cross-sectional difference in the sensitivity of investment to cash flow where firms are classified a priori as financially constrained. Some researchers argue that this variation is caused by market imperfection; whereas some dispute that the sensitivity could stem from the correlation between cash flow and omitted or mis-measured investment opportunities. Several attempts have also been made at constructing alternative measures of investment opportunities or fitting in additional variables uncorrelated with the investment opportunities aiming to test whether the effect of cash flow on firm's investment remains significant. But, the results arising from these attempts are not that consistent. Some confirm that investment cash flow sensitivity can still be used as a sufficient measure of financial constraints, whereas other studies remain sceptical. On the whole, the literature on this field of study can be divided into three clusters. One of them on classifying firms according to the degree of financial constraints, another on using more adequate measures of the investment opportunities to tackle the measurement error issues and the rest is on using alternative variables to verify the performance of the cash flow sensitivity of investment or to bypass the dependency on it.

3.2.1 Classification of firms into financially more or less constrained groups

The seminal paper by Fazzari et al. (1988) use US firm-level data to inspect the differences in the sensitivity of investment to cash flow across groups of firms divided according to the degree of financial constraints. They classify low-dividend paying firms as more likely to face financial constraints and the investment level of such firms are found to be affected relatively more by the availability of cash flow in comparison with the high-dividend paying unconstrained firms and thus provide useful evidence in favor of the existence of financial constraints under capital market imperfections. The higher sensitivity of investment to cash flow for financially constrained firms has been scrutinized by a number of papers including Kaplan and Zingales (1997). Using information contained in the firms' annual reports and managements' statements on internal liquidity, they confirm investment of low-dividend paying firms to be less sensitive to cash flow. This conflicting finding with Fazzari et al. (1988) recommends that higher sensitivities of investment to cash flow may not be sufficiently used as evidence that firms are more financially constrained. The Kaplan and Zingales (1997) classification scheme has been condemned later by Fazzari et al. (2000) in terms of both classification criteria and degree of financial constraints. They criticize that self-serving managers' statements favoring their firms' financial status may not be a reliable evidence of the absence of financing constraints in most situations. Also the classification criteria used in Kaplan and Zingales (1997) may be unreliable measures of the relative degree of financing constraints as they make their classification from static perspective only. Kaplan and Zingales (2000) later claim that the comparative statics analysis of Fazzari et al. (2000) are in fact supportive to their earlier conclusions and the criticisms regarding their classification scheme and empirical results are unjustified. Allayannis and Mozumdar (2004) also doubted that the results in Kaplan and Zingales (1997) are mainly caused by the presence of financially distressed firms or outliers in their sample.

The opinions therefore are divided into two subsets and have been supported by their proponents. The deviation arises mainly because of the different ways they use to measure financial constraints, namely external and internal financial constraints (Guariglia, 2008). Proponents of Fazzari et al. (1988) use proxies to measure the extent of external financial constraints faced by the firms. Findings similar with those in Fazzari et al. (1988) are observed for young and small firms (Devereux and Schiantarelli, 1990, Oliner and Rudebusch, 1992, Kadapakkam et al., 1998, Shin and Kim, 2002), for firms having low or no credit rating (Calomiris et al., 1995), for firms having no affiliation with industrial groups (Hoshi et al., 1991, Shin and Park, 1999).

On the other hand, indicators related to the level of internal financial constraints faced by the firms have been adopted by the studies supporting Kaplan and Zingales (1997) view. Cleary (1999) construct an index of firm's financial strength using a number of such variables indicating the extent of internal liquidity of a firm (e.g. the current ratio, financial slack, net income margin, sales growth, debt ratio). Lamont et al. (2001) also calculate a multivariate index by weighting five similar variables (e.g. cash flow to fixed assets, market to book ratio, debt to total assets, dividends to fixed assets, and cash to fixed assets). Using varying combinations, some other classification indexes of financial constraints have also been developed. The appealing examples of these include the WW index of Whited and Wu (2006), the synthetic index of Musso and Schiavo (2008) and the SA index proposed by Hadlock and Pierce (2010).

Aggarwal and Zong (2006) adopt discriminant analysis to estimate a beginning-of-period financial constraint index using the variables used by Cleary (1999) and use that index to classify firms of the four largest industrialized countries (US, UK, Japan and Germany) into three financial constraint categories.[10] Estimating a Fazzari et al. (1988) type regression equation, they show most firms face constrained access to external finance due to financially imperfect and incomplete markets as a result of which investment levels are significantly positively influenced by the levels of internal cash flows after controlling for the investment opportunity set and the strength of this relationship increases with the degree of financial constraints faced by the firms.

The single or multiple factor classifications applied with the investment regression approach may not successfully separate firms with different levels of investment-cash flow sensitivity and create static and dynamic misclassification problem as already discussed. Hu and Schiantarelli (1998) first address the ex ante classification problem using endogenous switching regression methods with unknown sample separation, where the probability of being constrained or unconstrained is determined by a switching function of a vector of firm specific and some other characteristics that proxy for the severity of informational and agency problems. They interpret the varying effect of cash flow on investment across the two groups of US manufacturing firms in terms of imperfect substitutability between different sources of finance and their results provide strong evidence that such effects vary with the severity of agency cost problems. Hovakimian and Titman (2006), Almeida and Campello (2007), Adelegan and Ariyo (2008), Hobdari et al. (2009) also apply the switching regression technique for their financial constraints analysis. Hobdari et al. (2009) use accelerator model of investment instead of the Tobin's Q. Their results are also based on the assumption that a non-zero cash flow coefficient for unconstrained firms captures future investment opportunity.

[10] In discriminant analysis, first step is to establish two or more mutually exclusive groups according to some explicit group classification and they use fixed charge coverage ratio as the grouping criteria. Then, ten percent of top and bottom companies have been used to identify the extreme sets of companies with the highest and the lowest levels of financial constraints.

3.2.2 Measurement error in investment opportunities

The main shortcoming of the Fazzari et al. (1988) methodology arises from the fact that average Q may not be a very precise proxy for the shadow value of an additional unit of new capital and the significance of cash flow may give biased results. Erickson and Whited (2000, 2002) postulate that such biases induced by measurement error in Q can be substantial and may be responsible for the estimated coefficients on Q being low and those on cash flow being high. They attempt to tackle this problem by using a class of measurement error-consistent GMM estimators that utilize the information in the higher order moments of the data. After including the estimated error adjusted Q in their model, they find that cash flow turns out to be insignificant even for the financially constrained firms, but Q theory has good explanatory power once the measurement error problem is controlled for. Gomes (2001) and Alti (2003) also provide results against Fazzari et al. (1988) by saying that the significance of cash flow can also occur in the absence of capital market frictions.

Another major blow to the findings of Fazzari et al. (1988) comes from Bond and Cummins (2001), Bond et al. (2004), and Cummins et al. (2006). They construct more accurate measures of the fundamentals which affect the expected returns on investment by using firm-specific earnings forecasts from securities analysts and Cummins et al. (2006) name it "real Q". Once expected profitability is controlled for by using Institutional Brokers Estimate System (I/B/E/S) analysts' earnings forecasts, the correlation between investment spending and cash flow disappears in all subsamples of firms in their samples. Gilchrist and Himmelberg (1995) estimate a set of VAR (vector auto regression) forecasting equations including cash flow as one of the observable fundamentals to construct the expected value of marginal Q conditional on observed fundamentals and they term it as "Fundamental Q". Since cash flow is used as one of the determinants for Q in the VAR forecasting equations, hence the alleged role of cash flow in predicting marginal value of capital is controlled for and all the additional predictive power of cash flow can then be attributed to capital market imperfections. Furthermore, as they estimate a separate VAR system for each subsample of firms, the measure of “Fundamental Q” directly controls for the possibility that the information content of cash flow may differ between constrained and unconstrained groups. However, they find that investment still responds to cash flow even after controlling for it's role as a forecasting variable for future investment opportunities and suggest that the excess sensitivity of investment to cash flow is not spuriously generated by cash flow's ability to predict future investment opportunities.

Another way to address the measurement error issue is to estimate the Euler equation for the capital stock by avoiding the reliance on Q to measure expected profitability. The goal of this estimation is that the standard Euler equation derived under the assumption of perfect capital markets should be misspecified for the priori classified financially constrained firms, but not for the unconstrained ones. Whited (1992), Hubbard et al. (1995) and Ng and Schaller (1996) estimate the standard Euler equation and an Euler equation augmented with financial variables for various categories of firms using US data and Bond and Meghir (1994) estimate the same using UK data. Their results support that the standard Euler equation generally holds only for firms less likely to face financial constraints. The problem in this estimation technique is that it may not be able to detect the presence of financial constraints if the severity of such constraints remains roughly constant over time.

Bond et al. (2003) employ both error correction model and an Euler-equation specification for estimating their investment equations using panel data sets for manufacturing firms in four European countries, Belgium, France, Germany, and the United Kingdom, covering the period 1978-1989 to investigate the role played by financial factors in each country. They find that financial variables like cash flow and profit terms appear to be both statistically and quantitatively more significant in the UK and it's financial system performs less well in channeling investment funds to firms with profitable investment opportunities compared to the other three continental European countries. This is consistent with the suggestion that financial constraints on investment may be relatively severer in more market-oriented UK financial system.

3.2.3 Alternative ways to verify the performance of the cash flow sensitivity of investment

Agca and Mozumdar (2008) emphasize that if investment-cash flow sensitivity is linked with capital market imperfections, then it should decrease with factors that reduce these imperfections. Applying Erickson-Whited error correction estimations to US manufacturing firm data, they find significant cash flow effects on investment in most of their sub samples and through different time periods. Then they examine the investment-cash flow sensitivity of these firms in relation to five factors associated with capital market imperfections and find that investment-cash flow sensitivity decreases with increasing fund flows, institutional ownership, analyst following, antitakeover amendments and with the existence of a bond rating. Therefore, they conclude that the sensitivity of investments to the availability of internal funds cannot be interpreted solely as an artefact of measurement error.

Carpenter and Guariglia (2008) use UK firms' contracted capital expenditure to capture information about opportunities available only to insiders and thus not included in Q. The contracted capital expenditure variable reflects the insiders' evaluation of investment opportunities and it is defined as contracts entered into for the future purchase of capital items, expenditure on machinery, equipment, plant, vehicles, and buildings, for which nothing has been paid by balance sheet date. They use a panel of UK firms over the period 1983-2000 and classify the firms as financially constrained or unconstrained using number of employees as a measure of size. They estimate investment regressions applying the within group IV estimator and Arellano and Bond (1991) first-difference GMM estimator to control for unobserved firm-specific heterogeneity and the possible endogeneity of the regressors. When they include their new regressor along with Q and cash flow in their investment equation to assess the overall investment opportunities of the firm more comprehensively, the explanatory power of cash flow falls for large firms, but still plays a significant role on the small firms' investment. They explain this as evidence that cash flow may still play it's role in capturing the effects of capital market imperfections, at least for the small firms which are more likely to be financially constrained as well.

In another paper, Guariglia (2008) uses an error-correction specification instead of the Q model to bypass the measurement error issue. Using a panel of unquoted UK firms, she finds that the sensitivity of investment to cash flow responds differently according to the type of constraint. The resulting relationship between investment and cash flow is U shaped when the sample is divided on the basis of internal financial constraints and monotonically increasing with the degree of external financial constraints faced by firms. By combining both types of constraints, she finds that the sensitivity is particularly large when external constraints are strong and internal constraints are weak. These results suggest that the controversy about whether higher investment cash flow sensitivity can be used as evidence of financial constraints is probably due to different sample separation criteria, may not necessarily be due to the improper measurement of Q.

The switching regression framework employed by Hu and Schiantarelli (1998) address the problem of cash flow's controversial role by allowing the coefficient on cash flow to differ from zero in the low premium or unconstrained regime. Therefore, even if cash flow contains some information about future profitability, the estimated cash flow coefficient for the constrained firms will be relatively higher than that of the unconstrained firms. In one version of their model, they include sales-to-capital ratio as an additional regressor in the investment equation to control for a firm's future profit prospects adequately. Whereas, Hovakimian and Titman (2006) claim that their estimated sensitivity of investment expenditures to asset sales is less affected by the measurement error in their proxy for investment opportunities as it is not likely to be positively related to asset sales. Their switching regression results reveal that after controlling for investment opportunities and cash flows, cash from asset sales is a significant determinant of corporate investment expenditures and financially constrained firms are likely to invest more when they generate cash from asset sales, but this relation is invalidated for financially unconstrained firms, all listed on NYSE, AMEX and NASDAQ.

Exploring the idea that the financial constraint status is endogenously related to the tangibility of the firm's assets, Almeida and Campello (2007) show that investment-cash flow sensitivity for the constrained firms increases with the tangibility of their assets, but not so for unconstrained firms using the universe of manufacturing firms available from COMPUSTAT. Moreover, their switching regression results also show that asset tangibility affects the credit status of the firms and the investment-cash flow sensitivities are not monotonically related to the degree of financing constraints. They also claim that their proposed empirical testing strategy sidesteps the measurement and interpretation problem with Tobin's Q as it does not rely on a single comparison of the level of the estimated cash flow coefficients of constrained and unconstrained firms, but revolves around the marginal effect of asset tangibility on the impact of income shocks on spending under credit constraints. Even if the cash flow coefficient contains information about investment opportunities, it is improbable that the bias is higher both for constrained and for highly tangible firms.

Ascioglu et al. (2008) also find higher investment-cash flow sensitivity for firms with high information asymmetry, but they use the probability of informed trade (PIN) to classify firms as constrained which is a more direct measure of financial constraint. According to them, only the informed investors invest in gathering information about firms' prospects and trade on that information and probability of informed trading captures the information asymmetry between informed and uninformed investors. They also claim that financial constraints matter only at high levels of informational frictions and their results are robust to other alternative specifications that control for different time periods, firm size, debt capacity, and probable measurement error problem of Q.

While the above studies find domestic evidence on the impact of cash flow on investments, Islam and Mozumdar (2007) find international evidence of higher investment cash flow sensitivity for firms in countries with less developed financial markets. This supports that firms in such countries face greater external capital market frictions which disrupt the flow of funds to their most productive uses and force firms to rely more on internal financing for investments. They include interactions of different measures of financial development with cash flow within an investment equation to establish the above result using a pooled sample of firms from 31 countries over 11 years. They adopt several methodological considerations to tackle the measurement error and other problems and the result is robust to different estimation procedures, to six different measures of financial development and five different measures of cash flow.

This chapter is going to follow the model of Almeida and Campello (2007), but will use predicted corporate efficiency from the stochastic frontier analysis in addition to asset tangibility assuming that financial constraint status can be endogenously related to the efficiency as well. According to the theoretical background of the model used in chapter two, higher efficiency means easing agency conflicts which in effect makes way to optimal operating, financing and investing decisions taken for the firm and efficiency may also positively affect firm's access to external financing by rendering signal to creditors or investors about the actual status of the firm. So, it is possible that the predicted corporate efficiency may affect firms' investment responsiveness to internal funds and credit status as well. Our interpretation of constrained and unconstrained regimes will mainly be based on the difference in estimated coefficients of the internal liquidity and it's interaction terms with efficiency.

3.3 Methodology

The main advantage of the switching regression approach is that the extent of investment behavior differing across groups of firms and the set of multiple characteristics determining their likelihood of being financially constrained or unconstrained can be determined simultaneously. The single-factor classifications discussed earlier may not successfully separate firms with different sensitivity of investment to internal financing. The severity of financial constraints can even vary among firms of the same subgroup if other factors are not controlled for. On the other hand, multiple factor classifications increase the number of subsamples reducing the size of each group used for estimation or increase the number of interactive terms in single regressions and produce imprecise estimates. The switching regression approach allows controlling for multiple indicators that jointly determine the group in which a firm is likely to belong without the need for splitting the sample into many smaller parts or including many interaction terms and also allows assessing their statistical significance. Furthermore, the selection regression incorporates more information into the estimation of the separate investment regimes than that can possibly be captured by the creation of dummy variables or sample splits.

In the switching regression model, it is assumed that there are two different investment regimes, regime 1 and regime 2. While the number of investment regimes are taken as given, the points of structural change are not observable and are estimated together with the investment equation for each one of the regimes. Depending on the extent of financial constraints, a firm may operate in one of the two unobservable investment regimes and it's investment may be more or less sensitive to the availability of internal funds than in the other. The model is composed of the following system of three equations that are estimated simultaneously:

$$I_{1it} = X_{it}\beta_1 + \nu_{1it} \tag{3.1}$$

$$I_{2it} = X_{it}\beta_2 + \nu_{2it} \tag{3.2}$$

$$y^*_{it} = Z_{it}\alpha + \epsilon_{it} \tag{3.3}$$

Equations 3.1 and 3.2 are the structural equations that describe the investment behavior of firms in the alternative regimes. Equation 3.3 is the selection equation that determines a firm's propensity of being in one or the other investment regime. X_{it} are the determinants of corporate investment and Z_{it} are the determinants of a firm's likelihood of being in the first or the second investment regime at time t. β_1, β_2 and α are vectors of parameters and ν_1, ν_2 and ϵ are residuals. The observed investment, I_{it}, undertaken by firm i at time t, is defined as follows:

$$I_{it} = I_{1it},\ if\ y^*_{it} < 0 \tag{3.4}$$

$$I_{it} = I_{2it},\ if\ y^*_{it} \geq 0 \tag{3.5}$$

y^*_{it} is a latent variable measuring the tendency or the likelihood of being in the first or second regime. Firms will not be fixed in one regime, as described in equation (3.4-3.5), a transfer between the regimes occurs if y^*_{it} reaches a certain unobservable threshold value. It is assumed that the vector of error terms in the investment and switching functions $(\nu_{1it}, \nu_{2it}, \epsilon_{it})'$ is jointly normally independently distributed with mean zero and covariance matrix $\sum$, which allows a non-zero correlation between the shocks to investment and the shocks to firms' characteristics and endogenous switching between the two investment regimes, where

$$\sum = \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{1\epsilon} \\ \sigma_{21} & \sigma_2^2 & \sigma_{2\epsilon} \\ \sigma_{\epsilon 1} & \sigma_{\epsilon 2} & 1 \end{pmatrix} \tag{3.6}$$

Here, $var(\epsilon)$ is normalized to 1 as only α/σ_ϵ can be estimated in equation 3.3, but not α and σ_ϵ individually (Hovakimian and Titman, 2006).

The extent to which investment spending differs across the two regimes and the likelihood that firms are assigned to either regime are simultaneously determined. This approach yields separate regime-specific estimates for investment equations, dispensing with the need to use ex ante regime sorting. In order to fully identify the switching regression model, it is needed to determine which regime is the constrained and which regime is the unconstrained. The algorithm specified in equations (3.1-3.5) creates two groups of firms that differ according to their investment behavior. The theoretical priors about which firm characteristics and how they are associated with financial constraints are used to achieve this identification.

The model is estimated by the method of maximum likelihood, details of which can be found in Maddala and Nelson (1994), Hu and Schiantarelli (1998) and Hovakimian and Titman (2006). Although a specific regime in which a particular firm is in cannot be observed, but the probability with which each of the regime occurs can be calculated as follows:

Probability of being in regime 1 is $\Pr(\epsilon_{it} < -Z_{it}\alpha \mid I_{1it} = X_{it}\beta_1 + \nu_{1it})$

Probability of being in regime 2 is $\Pr(\epsilon_{it} \geq -Z_{it}\alpha \mid I_{2it} = X_{it}\beta_2 + \nu_{2it})$

The likelihood function of each observation is given by

$$\begin{aligned} l_{it} = & Pr(\epsilon_{it} < -Z_{it}\alpha \mid I_{1it} = X_{it}\beta_1 + \nu_{1it})Pr(I_{1it} = X_{it}\beta_1 + \nu_{1it}) \\ & + Pr(\epsilon_{it} \geq -Z_{it}\alpha \mid I_{2it} = X_{it}\beta_2 + \nu_{2it})Pr(I_{2it} = X_{it}\beta_2 + \nu_{2it}) \end{aligned} \tag{3.7}$$

Whether the data are better characterized by a model that allows for two regimes, as opposed to a single regime can be tested with a likelihood ratio test. This LR test is performed by comparing the fit of a model with one regime to that of a model with two regimes and the null hypothesis is a single regime can better describe the data in comparison with a two regime model.[11] The problem with a switching model is that under the restriction that the coefficients of the two investment regimes are equal, the parameters of the selection equation are not identified which complicates the calculation of the degrees of freedom. It is also possible that the asymptotic likelihood ratio statistic does not have a distribution. But the results of the Monte Carlo tests conducted by Goldfeld and Quandt (1976) suggest that the χ^2 distribution can be used to conduct a likelihood ratio test by defining the degrees of freedom as the sum of the number of constraints and the number of unidentified parameters.

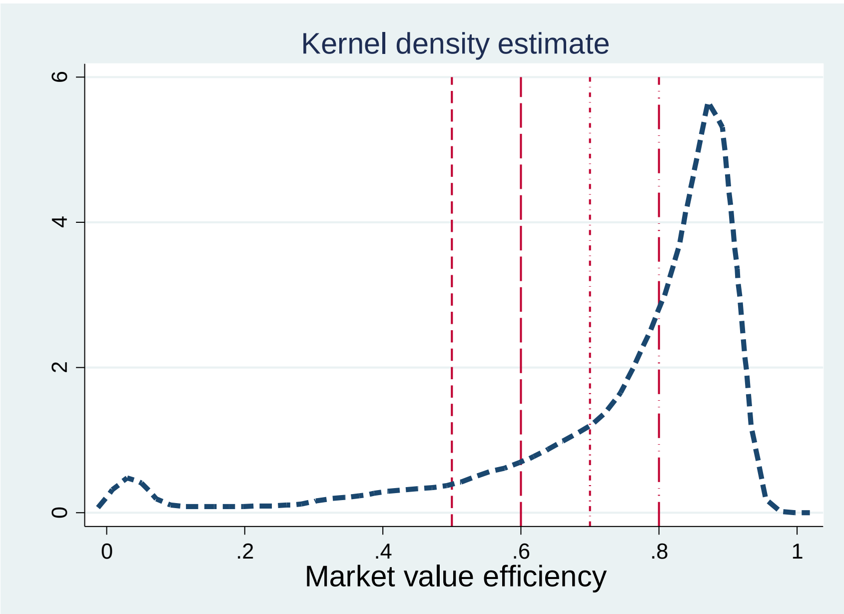
The ***switchr*** package for STATA written by Zimmerman (1998) will be used for estimating equations (3.1-3.3). The dependent variables in the two regime

[11] likelihood ratio test statistics = 2 {log-likelihood for alternative model - log-likelihood for null model}

specific equations (3.1) and (3.2) are investment and the dependent variable in the classification equation (3.3) is a classification variable. We have to provide an initial guess of this classification variable for each observations and ***switchr*** will return the estimated classification vector with the same name as the initial guess of the classification vector. The initial guess of the classification variable may be created using the corporate efficiency index estimated by the stochastic frontier analysis in the second chapter based on the assumption that highly efficient firms are most likely be financially unconstrained. For example, the observations will be coded as 1 (unconstrained) if their predicted efficiencies are above the 50th percentile value and 0 (constrained) otherwise. However, as the predicted market value efficiency is negatively skewed (figure 3.1), it may be a good idea to change the initial cut off point to 60th, 70th or 80th percentile values to check the sensitivity in the estimations. Since the estimated probabilities of observations belonging to any of the regimes are not generally just zero or one, the elements of the classification vector will fall throughout the interval [0; 1].

Figure 3.1: Cut off points for the predicted market value efficiency

The kernel density estimation of the predicted market value efficiency shows the negative skewness in it's distribution, which is why different cutoff points are used as threshold values for the initial firm classifications.



Two separate investment equations for the constrained and unconstrained group of firms and one corresponding switching equation will be estimated simultaneously for each of our model specification. We will check how consistent our results with theoretical underpinnings and previous empirical findings as well as concentrate on our main research questions.

3.4 Model Specification

3.4.1 Investment equation

The literature on investment has been dominated by two theories of investment, the neoclassical theory and the Q theory. According to the neoclassical theory, the financial component of a firm's user cost of capital does not depend on it's particular financial structure and the appropriate measure of investment opportunities is captured by the shadow value to the firm of an additional unit of physical capital. This guides firm's choice of the optimal capital stock (where expected marginal profitability equates to interest rate) to be solved without reference to any financial factors (Jorgenson, 1963, Hall and Jorgenson, 1967). The Q-theory of investment proposes that the ratio of the market value of capital stock to it's replacement cost could summarize investment opportunities and thus offers another formulation of the neoclassical model (Tobin, 1969). This is later extended to models of investment by Hayashi (1982), who claim that average Q can adequately capture investment opportunities and explain investment demand under the assumption of perfect competition, constant returns, capital as the only quasifixed factor and convex costs of adjusting the capital stock. These models are later augmented by financial variables to examine the effects of capital market imperfections contemplating that firms with higher net worth should invest more for given levels of investment opportunities, information costs, and market interest rates under the deviated market condition.

In this chapter, we rely on the extended Q theory of investment model to identify the difference in investment behavior across groups of firms in our switching regression framework. The variables that measure liquidity, predicted corporate efficiency, asset tangibility, interaction terms of efficiency and tangibility with cash flow are added to the basic reduced form equation of investment to form the X vector of equation 3.1 and 3.2. Rather than including firm dummies for each of the 1122 firms, we include sector dummies based on the assumption that firm characteristics will be similar within each of the 33 sectors classified by the FTSE/Dow Jones Industrial Classification Benchmark (ICB) codes. Year dummies are also included to capture year specific effects.

We estimate two different models in line with the existing literature and our propositions. As explained earlier, each of these models will have two identically specified investment equations and one different selection equation. In **model 1**, we include efficiency and it's interaction term with cash flow in the investment equations to check the magnitude and direction of investment-cash flow sensitivity and it's changing pattern with corporate efficiency across endogenously classified group of firms.

$$\begin{aligned} Investment_{it} = \beta_0 + \beta_1 Cash\ flow_{it} + \beta_2 (Cash\ flow * Efficiency)_{it} \\ + \beta_3 Fin.\ slack_{it} + \beta_4 Tobin's\ Q_{it} + \beta_5 Efficiency_{it} \\ + f_i + \tau_t + \nu_{it} \end{aligned} \tag{3.8}$$

In **model 2**, we additionally include asset tangibility and it's interaction with cash flow in the investment equations in a similar attempt to check the changing pattern of investment cash flow sensitivity with tangibility following Almeida and Campello (2007).

$$\begin{aligned} Investment_{it} = \beta_0 + \beta_1 Cash\ flow_{it} + \beta_2 (Cash\ flow * Efficiency)_{it} \\ + \beta_3 (Cash\ flow * Tangibility)_{it} + \beta_4 Fin.\ slack_{it} \\ + \beta_5 Tobin's\ Q_{it} + \beta_6 Efficiency_{it} + \beta_7 Tangiblity_{it} \\ + f_i + \tau_t + \nu_{it} \end{aligned} \tag{3.9}$$

Therefore, our interpretation does not depend only on a single comparison of the level of estimated cash flow coefficients between two groups of firms, but on multiple comparison of the coefficients of financial slack and two interaction terms as well. Our expected non monotonic effect of corporate efficiency on investment cash flow sensitivity may provide useful support in favor of cash flow's role in capturing financial market frictions by sidestepping the bias caused by the measurement error in Q.

3.4.2 Selection equation

The selection equation places a firm year observation in one of the more or less financially constrained regimes and the likelihood is endogenously determined in each period by multiple firm characteristics that proxy for the severity of informational and agency problems. This equation also allows assessing the statistical and economic significance of a given factor, while controlling for the information contained in other variables. We include the traditional criteria such as firms' size, age, dividend payout ratio and a set of balance sheet variables as an indicator of financial strength to form our selection vector Z in equation 3.3. We also include our predicted corporate efficiency index and tangibility in the selection vector in order to check how a firm's credit status changes with these two variables. As the general macroeconomic conditions are same for all firms in the economy or in a particular sector, their effects on the probability of facing any particular regime are expected to be same for all firms as well. Probably due to this same reason none of Hovakimian and Titman (2006) and Almeida and Campello (2007) include time and firm/industry dummies in their selection equations. We use the following selection equation in both **model 1** and **model 2** irrespective of the specification of the investment equation.

$$\begin{aligned} y^*_{it} = {} & \alpha_0 + \alpha_1 Size_{it} + \alpha_2 Age_{it} + \alpha_3 Dividend_{it} \\ & + \alpha_4 St.\ leverage_{it} + \alpha_5 Lt.\ leverage_{it} + \alpha_6 Tobin's\ Q_{it} \\ & + \alpha_7 Fin.\ slack_{it} + \alpha_8 Int.cov.ratio_{it} + \alpha_9 Efficiency_{it} \\ & + \alpha_{10} Tangibility_{it} + \epsilon_{it} \end{aligned} \tag{3.10}$$

3.4.3 Variables in the investment equation

Investment: The dependent variable investment is calculated as ratio of capital expenditure or additions to fixed assets to total tangible assets (I/K) following Hayashi (1982), Bond et al. (2004), Cummins et al. (2006), Aggarwal and Zong (2006) etc. Capital expenditures represent the funds used to acquire fixed assets. It includes additions to property, plant and equipment and investments in machinery and equipment etc.

Tobin's Q: Tobin's Q is used to capture firm's investment opportunity and similar to that in chapter two, it is calculated as the ratio of market value of assets to the book value of assets. Market value of assets is estimated as book value of total assets minus book value of equity plus market capitalization and book value of total asset is simply value of total assets.

Cash flow: Much empirical work on testing the presence of financial frictions rely on the fact that a change in net worth should effect investment and the sensitivity of investment to the firms' internal net worth should vary across firms with different characteristics. Cash flow is used as a standard proxy for firms' internal net worth and we would expect that the estimated coefficient on cash flow for the constrained firms exceeds the one for the unconstrained firms. We define cash flow as ratio of funds from operation to total assets following D'Espallier et al. (2008), Carpenter and Petersen (2002).

Financial slack: We include an additional financial variable as a measure of internal liquidity, financial slack (sum of cash and short term investment) to our investment equation. This is a stock measure of internal liquidity compared to the flow measure described above. According to Fazzari et al. (1988), such measure of firms' internal liquidity may also have an effect on investment for firms that facing asymmetric information problems in capital markets. As a low-cost source of investment finance for financially constrained firms, financial slack may provide them a financial cushion. Therefore, we would expect the coefficients for financial slack variables to be positive and higher for financially constrained firms similarly pointing to the inability of these firms to substitute between internal and external finance.

Tangibility: According to the theory of Almeida and Campello (2007), asset tangibility may increase investment for the financially constrained firms as it can ease such firm's access to external financing. An interaction term of asset tangibility with cash flow is also added by them to assess how the effect of cash flow varies with asset tangibility. We share the same thought and calculate tangibility as ratio of total tangible assets to total assets (Hovakimian, 2009).

Efficiency: Motivated by the idea of Agca and Mozumdar (2008), we include our predicted corporate efficiency by the stochastic frontier estimation and an interaction term of efficiency with cash flow to our investment equation. For inefficient and financially constrained firms, investment cash flow sensitivity is expected to decrease with efficiency. If the efficiency improves to a certain extent, the firms may become financially unconstrained and the effect of efficiency on their cash flow sensitivity may become inconsequential.

3.4.4 Variables in the selection equation

Size: Firm size has been used as one of the major proxy variables for the level of financial constraints (Devereux and Schiantarelli, 1990, Oliner and Rudebusch, 1992, Gertler and Gilchrist, 1994, Harris et al., 1994). Smaller firms are more vulnerable to information asymmetry problems and face higher and restricted access to external finance for a number of reasons (Bernanke et al., 1996). Firstly, transaction costs of issuing debt or equity tend to be higher for small firms. Secondly, small firms get less analyst coverage and comparatively little public information is available for them. Finally, small firms tend to be younger, less diversified and more prone to bankruptcy. We measure size as the natural logarithm of sales keeping similarity with chapter two.

Age: Similar to size, firm age has also been used as an important classification criteria as it may also create wedge between the costs of external and internal capital (Devereux and Schiantarelli, 1990, Oliner and Rudebusch, 1992). Younger firms are likely to be financially constrained and face severe agency cost problem. This is because, it is more difficult for financial institutions to gather information about young firms as they do not have a long track record. Similar to chapter two, natural logarithm of the number of years a firm appears in the chosen database is used as a proxy for firm age following Almeida and Campello (2007).

Dividend payout: High-dividend paying firms signal that they have good long-term prospects (Bhattacharya, 1979, John and Williams, 1985, Merton and Rock, 1985) and thus convey information to shareholders and outside world in an uninformed capital market. Firms with a high dividend payout ratio are less likely to face moral hazard and adverse selection problems and obtaining external finance will be relatively easier for them. Previous studies have used a dummy variable which is equal to one if a firm paid out dividends and zero otherwise. But this places all the dividend paying firms in the same group failing to capture the extent of dividend payment. We instead include the ratio of total cash dividend paid to total assets and firms that pay out higher dividends are expected to be less financially constrained.

Leverage: Highly levered firms are expected to be suffering from lack or exhaustion of collateralizable assets and therefore their ability to raise external financing may be impaired. However, high leverage for a certain group of firms may also be interpreted as high debt capacity and lower financial constraints (Hovakimian, 2009). Also agency cost problems in highly levered firms may be mitigated due to reduction of free cash flow (Jensen, 1986) or strict monitoring by the lenders (Agrawal and Knoeber, 1996) which may help the firms to obtain further external financing. To control for these and also to differentiate between the effects of short term and long term debt on the firm's probability of facing financial constraints, we include short-term leverage and long-term leverage, both scaled by the book value of total assets. The same approach is followed by Hovakimian and Titman (2006) and Almeida and Campello (2007).

Interest coverage ratio: Along with leverage, we also include a flow measure of indebtedness, interest coverage ratio. We calculate interest coverage ratio as ratio of interest expense on debt to earnings before interest, taxes and depreciation (EBITD) following Hovakimian and Titman (2006) and the expected sign of it's estimated coefficient should be aligned with those of leverage.

Tobin's Q: Tobin's Q is also included in the selection equation, but it has an ambiguous role on firm's likelihood of facing one particular regime. On one hand, firms having better investment opportunity may be in greater need of financing and thus are likely to be more financially constrained. On the other hand, a firm will enjoy easier access to external finance if the firm's growth opportunities are recognized by the market. Hu and Schiantarelli (1998) give another justification of adding Tobin's Q in the selection equation which is to control for problems associated with free cash flow and they expect firms with low Q to face severe agency problems.

Financial slack: The sum of cash and short term investment or financial slack is also included as a determinant of financial constraints. Kaplan and Zingales (1997), Kashyap et al. (1994) assert that firms with high levels of liquid assets may not be liquidity constrained as their investment is not limited by a lack of finance. On the contrary, Fazzari et al. (2000), Kim et al. (1998) recommend that firms have more incentive to hold high levels of financial slack if they are financially constrained or contemplating to be so. Calomiris et al. (1995) support this view by showing that firms with low or no-credit quality ratings tend to hold larger stocks of liquid assets and demonstrate financially constrained behavior.

Tangibility: Almeida and Campello (2007) initiated asset tangibility as a classification criterion as well. They believe that asset tangibility increases a firm's ability to obtain external financing because tangible assets increases value that can be captured by creditors in default states. Moreover, asset tangibility reduces asymmetric information problems because tangible assets' payoffs are easier to observe. All these make firms with more tangible assets less financially constrained.

Efficiency: According to theoretical underpinnings, the severity of the agency cost problems raises the cost of external financing and worsens a firm's leverage capacity. So, we include our predicted direct measure of inverse agency cost in our selection equation assuming that efficiency may affect credit status of the firms. We expect that the higher (lower) the efficiency (agency cost) of a particular firm, the lower will be the firm's probability of facing constrained financial status.

3.5 Data and descriptive statistics

We use the same data as in chapter two, collected from the Worldscope Global Database. We have an unbalanced panel of 1122 firms from thirty three different sectors from 1981 to 2009 with a minimum of three to a maximum of twenty nine consecutive years of observations and a total of 13183 firm-years. These thirty three sectors are differentiated according to FTSE/Dow Jones Industrial Classification Benchmark (ICB) codes. All financial variables are deflated with GDP deflator and all regression variables are winsored at the 1% and 99% level to get rid of the extreme outliers. Table 3.1 reports means and distributional information for all the regression variables we use in this chapter. Some of the variables in the table overlap with those used in chapter two.

Cash flow representing the flow measure of internal liquidity has mean value of 3.88%, but there are 21% firm year observations with negative cash flows. On the contrary, the stock measure of internal liquidity has mean value of 15.79%. This stock measure doesn't have any negative observations, but there are firms with no such short term investment. Recent literature suggests eliminating firm years with Tobin's Q in excess of 10 as an attempt to tackle the measurement error problem of investment opportunities (Almeida and Campello, 2007). As the maximum of 12.69 for Tobin's Q in our data is close to the suggested cut-off point, this is expected to minimize the probable measurement problem to some

Table 3.1: Descriptive Statistics

This table gives mean and distributional information for all the regression variables for which data is collected from the Worldscope Global Database for 1122 UK firms listed on the London Stock Exchange over the period 1981 to 2009. All financial variables are deflated with GDP deflator and all regression variables are winsored at the 1% and 99% level to get rid of the extreme outliers. Tobin's Q is calculated as the ratio of market value of assets to the book value of assets. Market value is estimated as book value of total assets minus book value of equity plus market capitalization and book value of total asset is simply value of total assets. Natural logarithm of total sales and natural logarithm of the number of years a firm appears in the database are used as proxies for firm size and firm age respectively. Financial slack (Fin.slack) is calculated as ratio of cash and short term investment to total assets; cash flow as ratio of funds from operation to total assets; tangibility as ratio of total tangible assets to total assets; interest coverage ratio (Int.cov.ratio) as ratio of interest expense on debt to earnings before interest, taxes and depreciation; dividend payout as ratio of total cash dividend paid to total assets and investment as ratio of capital expenditure or additions to fixed assets to total tangible assets. Short term debt (St.leverage) and long term debt (Lt.leverage) are both scaled by total assets. Market value efficiency (Mv.efficiency) and profit efficiency (Pr.efficiency) are the corporate efficiency indexes derived from the estimated market value and profit frontiers respectively in chapter two.

	Mean	SD	Min	Q1	Median	Q3	Max
Investment	.2787	.2381	.0004	.1194	.2045	.3582	1.193
Cash flow	.0388	.2001	-1.015	.0198	.0836	.1345	.3385
Tobin's Q	2.033	1.864	.5193	1.072	1.464	2.178	12.69
Tangibility	.2900	.2386	.0021	.0873	.2453	.4253	.9220
Mv.efficiency	.7454	.2007	.0056	.6957	.8214	.8760	1
Pr.efficiency	.8663	.1625	.0994	.8530	.9332	.9595	1
Size	10.92	3.243	4.301	9.448	11.28	12.97	16.74
Age	2.114	0.862	0	1.609	2.303	2.833	3.367
Dividend	.0207	.0240	0	0	.0157	.0312	.1312
St.leverage	.0621	.0892	0	.0017	.0281	.0844	.4937
Lt.leverage	.1043	.1352	0	.0003	.0524	.1596	.6539
Fin.slack	.1579	.1843	0	.0320	.0936	.2062	.8671
Int.cov.ratio	.0838	.2728	-1.318	0	.0583	.1489	1.381

extent. The sample contains unlevered firms as well as highly levered firms if we consider any of the short term or long term debt positions. An average firm is seen to be more dependent on long term debt with mean value of 10.43% compared to 6.21% of the short term debt. This divergence between the two sources of external financing is almost consistent throughout the sample. The flow measure of indebtness, interest coverage ratio has a mean value of 8.38% and supports the dependency of an average firm on external debt as well. The level of investment of an average firm is 27.88% with a median value of 20.45%. And finally an average firm in our sample is 74.5% and 86.6% efficient compared to it's best performing peers, predicted from our market value and profit frontiers respectively.

3.6 Empirical results

3.6.1 Effect of efficiency on investment cash flow sensitivity

Model 1 of table 3.2 gives the maximum likelihood estimation results of our first switching regression model (equation 3.8 along with equation 3.10). As explained earlier, the result is composed of three parts. One selection equation presented in table 3.2.a which determines a firm's likelihood of being in a constrained or unconstrained regime and two separate investment equations for constrained and unconstrained groups presented in table 3.2.b which demonstrates how different the firms' investment behavior across the two groups. The investment equations are estimated with sector and year dummies and clustering by company ID is used to correct the error structure of the estimations.

The dependent variable in the selection equation is coded 1 for the unconstrained investment regime and 0 for the constrained one and as explained in the methodology section, this coding is made using our predicted corporate efficiency index. The observations having predicted efficiencies above the 50th percentile value has been coded as 1 (unconstrained) and 0 (constrained) otherwise. It is in line with the theoretical prior that firms suffering less from the agency cost related problems enjoy relatively easier access to external financing source. As explained earlier, we use other cutoff points due to the negatively skewed distribution of the predicted efficiency. These coding of the dependent variable are only needed to provide the initial guess required by the ***switchr*** package to work. As we see later, use of different cutoff points do not make any changes in the estimated results because ***switchr*** creates it's own classification vector based on the selection variables in the Z vector of equation 3.10. A positive coefficient of any selection variable indicates that firms with higher values of that particular variable are more likely to be in the unconstrained regime or a firm's likelihood of facing financially unconstrained regime is positively related with that selection variable. The relationship will be reversed for any selection variable having a negative coefficient. P-value tests the null hypothesis that a single investment regime is sufficient to describe the data as opposed to two regimes.

The result supports the general consensus that larger, older and high dividend paying firms are more likely to be in the financially unconstrained regime as these firms are less susceptible to the effects of information asymmetries. The negative coefficient for Tobin's Q hints that firms may not be financially constrained when they do not have better investment opportunity. Negative coefficient for financial slack is also expected as financially constrained firms have the urge to hold assets in such short term and liquid form. Our estimated coefficient for this variable has positive sign, but statistically insignificant. Tangible asset's positive effect on firm's credibility to external financiers is also supported by our findings. All the above explanations and subsequent findings are in line with those given in Hu and Schiantarelli (1998), Hovakimian and Titman (2006) and Almeida and Campello (2007). Our two stock measures of indebtedness, short term and long term leverage and also the corresponding flow measure, interest coverage ratio have positive and statistically significant coefficients. These results indicate that firms with a high level of external debt are associated with a lack of financial constraints or are less dependent on internally generated funds probably due to their high debt capacity or reduced agency cost problems. In other words, these firms may likely to find it easy to convince lenders to provide them with external credit on the strength of their collaterizable assets and proven track record. Hovakimian and Titman (2006) find similar intuition for their sample firms in the decade of 1990-91. According to our hypothesis and theoretical background behind predicted corporate efficiency, firm's efficiency has significant effect on the credit status of the firm. The more efficient a particular firm is or less severe the agency cost problems, the lower is the firm's probability of facing constrained financial status.

Table 3.2: Switching regression models with market value efficiency

This table gives the maximum likelihood estimation results of our two switching regression models (investment equations 3.8 and 3.9 along with the selection equation 3.10). The selection equation determines a firm's likelihood of being in a constrained or unconstrained regime. The dependent variable in the selection equation is coded 1 for the unconstrained investment regime and 0 for the constrained one. A positive coefficient of any selection variable indicates that firms with higher values of that particular variable are more likely to be in the unconstrained regime and vice versa. P-values of the models reject the null hypothesis that a single investment regime is sufficient to describe the data. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

Table 3.2.a: Selection equations

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
Size	0.021***	0.004	0.027***	0.004
Age	0.449***	0.010	0.465***	0.010
Dividend	0.039***	0.002	0.042***	0.002
St.leverage	0.768***	0.054	0.497***	0.061
Lt.leverage	0.524***	0.046	0.428***	0.045
Tobin's Q	-0.055***	0.005	-0.072***	0.005
Int.cov.ratio	0.182***	0.014	0.158***	0.014
Fin.slack	0.042	0.050	-0.234***	0.049
Mv.efficiency	0.657***	0.070	0.866***	0.072
Tangibility	2.452***	0.024	1.304***	0.025
Constant	-1.344***	0.042	-1.232***	0.043
Model p-values		0.000		0.000

Table 3.2 continues on next page.

Table 3.2.b represents the estimation results of the regime specific investment equations derived simultaneously with the selection equation. The results reveal that the investment behavior is significantly different between the constrained

Table 3.2.b: Investment equations

Two separate investment equations for each of the models demonstrate how different the firms' investment behavior across the two regimes. The investment equations are estimated with sector and year dummies and clustering by company ID is used to correct the error structure of the estimations. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
	Unconstrained			
Cash flow	0.078**	0.037	0.065*	0.037
Cash flow*Mv.efficiency	0.098**	0.049	0.031	0.050
Cash flow*Tangibility			0.383***	0.066
Fin.slack	0.121***	0.014	0.047***	0.014
Tobin's Q	0.019***	0.001	0.017***	0.001
Mv.efficiency	-0.016	0.020	-0.011	0.018
Tangibility			-0.205***	0.012
Constant	0.163***	0.020	0.216***	0.019
	Constrained			
Cash flow	0.232***	0.059	0.185***	0.059
Cash flow*Mv.efficiency	-0.301***	0.083	-0.270***	0.082
Cash flow*Tangibility			0.229**	0.090
Fin.slack	0.157***	0.023	0.060**	0.023
Tobin's Q	0.030***	0.002	0.027***	0.002
Mv.efficiency	-0.474***	0.029	-0.438***	0.028
Tangibility			-0.337***	0.030
Constant	0.559***	0.054	0.641***	0.057

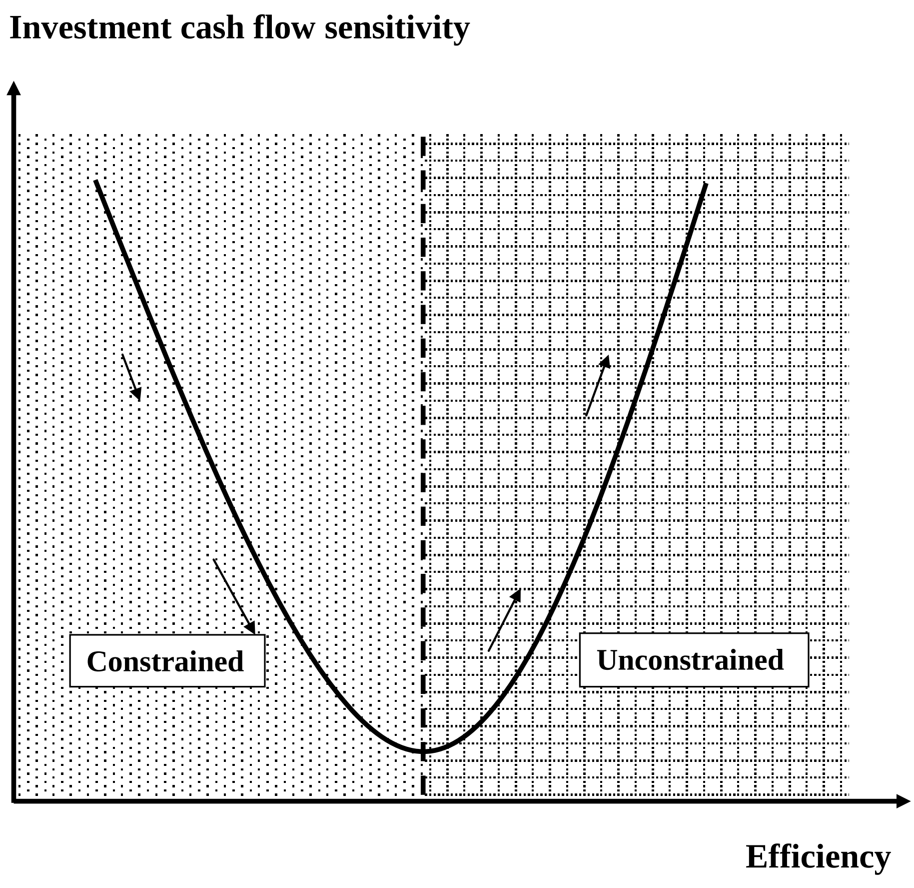
and unconstrained regimes. The coefficients of Tobin's Q are positive in the two regimes as firms having better investment opportunity are expected to invest more. Investment is positively and significantly related to cash flow and the stock of cash in both the regimes, but as expected magnitudes of the estimated coefficients for these two variables are larger in the constrained regime than those in the unconstrained regime. This clearly implies that financially constrained firms' investment is more sensitive to internal liquidity due to their inconvenience to easily switch between internal and external finance. Most interestingly, investment cash flow sensitivity for financially constrained firms is found to be decreasing with corporate efficiency as opposed to increasing in the unconstrained regime. Such contrasting behavior of the two group of firms may be explicated by the cost and revenue effect suggested by Cleary et al. (2007). This along with the perceived effect of efficiency on firms' credit status suggest important implication.

Firms are financially constrained at low level of efficiency, but their investment becomes less and less sensitive to the availability of internal funds as their level of corporate efficiency perks up. Higher efficiency makes the agency conflict less severe and enables the firms' managers to take optimal financing and investment decisions and potentially earn higher revenue for these firms. This may switch on the "revenue effect" as higher revenue is expected to lower the firms' default risk subsequently. Therefore, the hindrance to constrained firms' access to external financing source may become less acute with improvement in their efficiency making them less intensely dependent on internally generated funds. Once these firms' efficiency reaches to a certain standard, they may become financially unconstrained. These unconstrained firms may have high levels of internal funds, but this may still be insufficient to finance all of their investment requirements. This may require higher borrowing, higher repayment costs and consequently bring in a higher risk of default. This "cost effect" may be responsible for their investment to become increasingly sensitive to cash flow as efficiency increases further. However, we should not be concerned about this positive effect of efficiency on their investment cash flow sensitivity considering that they are not likely to be financially constrained, either internally or externally and they are likely to have the privilege to choose the right mix of internal and external financing.

Overall, our findings indicate a non monotonic effect of corporate efficiency on cash flow sensitivities. At lower level of efficiency, firms are financially constrained and their investment cash flow sensitivity decreases with efficiency. When efficiency reaches to a certain level, the firms switch from constrained to unconstrained status and their investment cash flow sensitivity starts to increase with efficiency. This is in line with our prediction that the financial constraint status may be endogenously related to the corporate efficiency of the firms. To be specific, the relationship between investment cash flow sensitivity and corporate efficiency may be U shaped as shown in figure 3.2. The figure is hypothetically drawn resembling with the findings explained so far. The level of efficiency where the status changes from constrained to unconstrained can not be observed, but as explained earlier, our main interest lies on the left part of the figure where efficiency drives down the comparatively high investment cash flow sensitivity for the financially constrained firms and eventually makes them financially unconstrained.

Figure 3.2: Non monotonic relationship between investment cash flow sensitivity and efficiency

This figure shows the non monotonic effect of corporate efficiency on the investment cash flow sensitivities of the firms. Investment cash flow sensitivity is found to be decreasing with efficiency for financially constrained firms. Once these firms' efficiency reaches to a certain level, they become financially unconstrained and their investment cash flow sensitivity starts increasing.



Our findings reveal important evidence in resolving the controversial role of cash flow in detecting the presence of capital market imperfection. If higher sensitivity of investments to cash flow for the financially constrained firms is solely generated because of the measurement error issue, then it shouldn't be decreasing with improvement in efficiency or agency cost. Analogues to the findings of Agca and Mozumdar (2008), our results support the idea that cash flow may still claim it's role in seizing the effects of capital market imperfections, at least for the financially constrained firms. Moreover, the results are free from the priori classification bias as these constrained firms are endogenously classified by our model.

3.6.2 Credit multiplier effect

Model 2 of table 3.2 gives the maximum likelihood estimation results of our second switching regression model (equation 3.9 along with equation 3.10). Here as well, the investment equations are estimated with sector and year dummies and clustering by company ID is used to correct the error structure of the estimations.

Results of the selection equation of model 2 in table 3.2.a are almost similar as that of model 1. Firms that are larger, older, have lower market-to-book ratio, have lower financial slack, pay high dividends, more efficient and have more tangible assets are more likely to operate in the unconstrained regime. Highly levered firms' possibility of facing unconstrained credit status remains valid in this model as well. The findings of the two investment equations of our second model in table 3.2.b are also consistent with those of the first. Firms operating in the constrained investment regime demonstrate higher sensitivity to our two measures of internal liquidity. The changing credit status of firms with efficiency is also present here. Most importantly, the constrained firms' investment cash flow sensitivity decreases with efficiency in this extended model specification as well. However, the increase in the investment cash flow sensitivity with efficiency for the unconstrained firms is not found statistically significant.

In this model, the additional variables included in the investment equations are tangibility and it's interaction terms with cash flow pursuing Almeida and Campello (2007)'s effort. Making use of the Kiyotaki and Moore (1997) credit multiplier model, they find that asset tangibility amplifies the effect of exogenous income shock on the investment spending of financially constrained firms only and raises their investment-cash flow sensitivity. According to them, these firms are better able to increase their collateral value by investing more in pledgable assets following a positive income shock which in turn allows them to raise more external financing, which in turn allows for more investment, and so on. However, at some point these firms become unconstrained and tangibility should no more affect their investment-cash flow sensitivity. We find positive and significant effect of tangibility on the investment cash flow sensitivity for both the groups. Not only that, our estimated coefficients suggest that the credit multiplier mechanism is stronger for the unconstrained firms in our sample. It may be argued here that such positive relation between cash flow and external financing should be particularly strong for those firms with high tangible assets as new investment in more collateralizable assets may enhance their credit capacity more than what is observed for firms with less tangible assets (Almeida and Campello, 2010). In a nutshell, our resulting relationship between tangibility and investment cash flow sensitivity is monotonic in contrast with the previous findings.

3.6.3 Predicted probability of facing financially unconstrained regime

Another important outcome of the switching regression model is that it calculates probabilities of firm years operating in the financially unconstrained regime and this can be used as a single time varying and continuous indicator of credit status. Table 3.3 gives the mean and distributional information for the predicted likelihood of facing financially unconstrained status (PFU) from the two models in table 3.2. As both of them are predicted from the same selection equation, it is not surprising that they are quiet similar in terms of their distributions, in terms of the rank correlation (.971) and also in terms of their correlation with the selection variables. The correlation matrix of the PFU's with the selection variables are presented in table B.1 of appendix B (p. 165).

Table 3.3: Probability of facing financially unconstrained regime

This table gives mean and distributional information for our predicted probability of facing financially unconstrained regime from model 1 and 2 of table 3.2.

	Mean	SD	Skewness	Min	Q1	Median	Q3	Max
PFU_{Model1}	.857	.186	-1.684	.111	.793	.943	.985	.999
PFU_{Model2}	.864	.181	-1.955	.064	.819	.946	.980	.999

3.6.4 Robustness check

We conduct a series of robustness check of our proposed hypothesis and results. Firstly, it could be a matter of concern to create the initial classification variable (dependent variable, y^*_{it}) of our selection equation 3.10 using efficiency and at the same time including efficiency as an independent variable of the same equation. In order to tackle this, we estimate both the models excluding efficiency from the Z vectors. The results reported in table 3.4 are found robust to this change in the model specification. Our suggested effect of efficiency on firm's credit status is still sustained by the resulting non monotonic relationship between efficiency and investment cash flow sensitivity.

Table 3.4: Switching regression models excluding efficiency from the selection equation

This table gives the maximum likelihood estimation results of our two switching regression models. Here, market value efficiency is excluded from the selection equation to check robustness of our earlier results. The selection equation determines a firm's likelihood of being in a constrained or unconstrained regime. The dependent variable in the selection equation is coded 1 for the unconstrained investment regime and 0 for the constrained one. A positive coefficient of any selection variable indicates that firms with higher values of that particular variable are more likely to be in the unconstrained regime and vice versa. P-values of the models reject the null hypothesis that a single investment regime is sufficient to describe the data. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

Table 3.4.a: Selection equations

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
Size	0.057***	0.003	0.074***	0.003
Age	0.439***	0.010	0.454***	0.010
Dividend	0.036***	0.002	0.037***	0.002
St. leverage	0.799***	0.053	0.531***	0.060
Lt. leverage	0.497***	0.046	0.394***	0.045
Tobin's Q	-0.034***	0.004	-0.045***	0.004
Int.cov.ratio	0.183***	0.014	0.157***	0.014
Fin.slack	0.007	0.049	-0.269***	0.049
Tangibility	2.505***	0.024	1.376***	0.024
Constant	-1.248***	0.037	-1.112***	0.038
Model p-values		0.000		0.000

Table 3.4.b: Investment equations

Two separate investment equations for each of the models demonstrate how different the firms' investment behavior across the two regimes. The investment equations are estimated with sector and year dummies and clustering by company ID is used to correct the error structure of the estimations.

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
	Unconstrained			
Cash flow	0.074**	0.038	0.059	0.037
Cash flow*Mv.efficiency	0.105**	0.050	0.040	0.050
Cash flow*Tangibility			0.384***	0.066
Fin.slack	0.119***	0.014	0.045***	0.014
Tobin's Q	0.020***	0.001	0.017***	0.001
Mv.efficiency	-0.020	0.020	-0.016	0.019
Tangibility			-0.204***	0.012
Constant	0.167***	0.020	0.220***	0.020
	Constrained			
Cash flow	0.232***	0.059	0.187***	0.059
Cash flow*Mv.efficiency	-0.294***	0.083	-0.271***	0.082
Cash flow*Tangibility			0.235***	0.091
Fin.slack	0.151***	0.023	0.056**	0.024
Tobin's Q	0.030***	0.002	0.027***	0.002
Mv.efficiency	-0.492***	0.029	-0.460***	0.028
Tangibility			-0.332***	0.030
Constant	0.566***	0.054	0.647***	0.056

Following Hu and Schiantarelli (1998), we also include sales-to-capital ratio as an additional regressor in our investment equations to reduce the possible role of cash flow as a predictor of firm's future profit prospects and to capture possible effects of imperfect competition in the output market. We do the same for our two models and the results are reported in table 3.5. As expected, magnitude of the estimated cash flow coefficient declines for both the constrained and unconstrained regimes which may be due to the correlation between cash flow and sales. However, the pattern of the cash flow coefficients across the two regimes remain same as in the models without sales. Investment continues to show higher sensitivity to our two internal liquidity measures for the constrained firms and also the variation of the investment cash flow sensitivity with efficiency and tangibility and their divergence between the two regimes persists.

Table 3.5: Switching regression models with sales-to-capital ratio

This table gives the maximum likelihood estimation results of our two switching regression models. Here, sales-to-capital ratio is added to the investment equations to check robustness of our earlier results. The selection equation determines a firm's likelihood of being in a constrained or unconstrained regime. The dependent variable in the selection equation is coded 1 for the unconstrained investment regime and 0 for the constrained one. A positive coefficient of any selection variable indicates that firms with higher values of that particular variable are more likely to be in the unconstrained regime and vice versa. P-values of the models reject the null hypothesis that a single investment regime is sufficient to describe the data. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

Table 3.5.a: Selection equations

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
Size	0.039***	0.004	0.035***	0.004
Age	0.436***	0.010	0.456***	0.010
Dividend	0.050***	0.002	0.046***	0.002
St. leverage	0.560***	0.065	0.499***	0.064
Lt. leverage	0.405***	0.046	0.376***	0.045
Tobin's Q	-0.064***	0.005	-0.067***	0.005
Int.cov.ratio	0.158***	0.014	0.148***	0.014
Fin.slack	-0.071	0.049	-0.216***	0.049
Mv.efficiency	0.488***	0.071	0.657***	0.072
Tangibility	1.602***	0.024	1.142***	0.024
Constant	-1.185***	0.042	-1.146***	0.042
Model p-values		0.000		0.000

Table 3.5 continues on next page.

Table 3.5.b: Investment equations

Two separate investment equations for each of the models demonstrate how different the firms' investment behavior across the two regimes. The investment equations are estimated with sector and year dummies and clustering by company ID is used to correct the error structure of the estimations.

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
	Unconstrained			
Cash flow	0.052	0.037	0.061	0.037
Sales/Capital	0.002***	0.0001	0.001***	0.0001
Cash flow*Mv.efficiency	0.168***	0.048	0.050	0.050
Cash flow*Tangibility			0.357***	0.063
Fin.slack	0.106***	0.013	0.058***	0.013
Tobin's Q	0.017***	0.001	0.016***	0.001
Mv.efficiency	-0.010	0.018	-0.011	0.018
Tangibility			-0.147***	0.013
Constant	0.154***	0.019	0.197***	0.019
	Constrained			
Cash flow	0.146**	0.058	0.174***	0.059
Sales/Capital	0.002***	0.0001	0.002***	.0002
Cash flow*Mv.efficiency	-0.102	0.082	-0.246***	0.082
Cash flow*Tangibility			0.266***	0.086
Fin.slack	0.151***	0.022	0.088***	0.022
Tobin's Q	0.030***	0.002	0.030***	0.002
Mv.efficiency	-0.543***	0.028	-0.518***	0.028
Tangibility			-0.201***	0.030
Constant	0.598***	0.061	0.636***	0.061

The models estimated so far include all contemporary variables, both in the selection and the investment equation. The variables like cash flow, financial slack, Tobin's Q in the investment equation may create endogeneity problems. To account for that, we reestimate the two models replacing the contemporary explanatory variables in the investment equation by their one year lagged values keeping variables in the selection equation same as before. In this case, the selection equation still determines whether the contemporary investment belongs to the constrained and unconstrained regime, but that contemporary investment is now explained by one year lagged explanatory variables. The outcomes are reported in table 3.6 and assert the results already obtained.

Table 3.6: Switching regression models controlling for endogeneity

This table gives the maximum likelihood estimation results of our two switching regression models. Here, all the right hand side variables in the investment equation are included as one year lagged to check for endogeneity problems in our earlier results. The selection equation determines a firm's likelihood of being in a constrained or unconstrained regime. The dependent variable in the selection equation is coded 1 for the unconstrained investment regime and 0 for the constrained one. A positive coefficient of any selection variable indicates that firms with higher values of that particular variable are more likely to be in the unconstrained regime and vice versa. P-values of the models reject the null hypothesis that a single investment regime is sufficient to describe the data. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

Table 3.6.a: Selection equations

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
Size	0.031***	0.004	0.0003	0.004
Age	0.437***	0.010	0.461***	0.010
Dividend	0.045***	0.002	0.041***	0.002
St. leverage	0.489***	0.061	0.472***	0.063
Lt. leverage	0.654***	0.047	0.427***	0.045
Tobin's Q	-0.108***	0.005	-0.103***	0.005
Int.cov.ratio	0.117***	0.015	0.148***	0.014
Fin.slack	-0.148***	0.051	-0.008	0.050
Mv.Efficiency	0.995***	0.070	1.449***	0.073
Tangibility	2.890***	0.024	1.740***	0.023
Constant	-0.955***	0.041	-1.373***	0.043
Model p-values		0.000		0.000

Table 3.6 continues on next page.

Table 3.6.b: Investment equations

Two separate investment equations for each of the models demonstrate how different the firms' investment behavior across the two regimes. The investment equations are estimated with sector and year dummies and clustering by company ID is used to correct the error structure of the estimations.

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
	Unconstrained			
L.Cash flow	0.079**	0.036	0.031	0.040
L.Cash flow*L.Mv.Efficiency	0.120**	0.048	0.083	0.054
L.Cash flow*L.Tangibility			0.350***	0.070
L.Fin.slack	0.151***	0.014	0.071***	0.014
L.Tobin's Q	0.019***	0.001	0.016***	0.001
L.Mv.Efficiency	0.033**	0.016	0.034*	0.018
L.Tangibility			-0.222***	0.013
Constant	0.124***	0.018	0.187***	0.019
	Constrained			
L.Cash flow	0.226***	0.056	0.168***	0.055
L.Cash flow*L.Mv.Efficiency	-0.297***	0.077	-0.273***	0.069
L.Cash flow*L.Tangibility			0.239***	0.079
L.Fin.slack	0.192***	0.022	0.069**	0.024
L.Tobin's Q	0.017***	0.002	0.015***	0.002
L.Mv.Efficiency	-0.276***	0.029	-0.219***	0.035
L.Tangibility			-0.377***	0.036
Constant	0.213***	0.044	0.197***	0.047

We replace the predicted market value efficiency with the profit efficiency in our attempt to check how robust our already established results to this alternative form of corporate efficiency. The results presented in table 3.7, are robust and firm's credit status is similarly affected by profit efficiency as well. The higher the profit efficiency (less severe agency cost) of a particular firm, the better is it's possibility to enjoy unrestricted access to external capital and as a result, it's investment becomes less sensitive to the measures of internal funds. Not only that, investment cash flow sensitivity is still non monotonically related with profit efficiency. The sensitivity decreases with profit efficiency for the constrained firms and increases for the unconstrained. The coherence of our results is logical if we recall that our both forms of predicted efficiencies have a positive rank correlation between them.

Table 3.7: Switching regression models with profit efficiency

This table gives the maximum likelihood estimation results of our two switching regression models. Here, market value efficiency is replaced by the profit efficiency to check robustness of our earlier results. The selection equation determines a firm's likelihood of being in a constrained or unconstrained regime. The dependent variable in the selection equation is coded 1 for the unconstrained investment regime and 0 for the constrained one. A positive coefficient of any selection variable indicates that firms with higher values of that particular variable are more likely to be in the unconstrained regime and vice versa. P-values of the models reject the null hypothesis that a single investment regime is sufficient to describe the data. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

Table 3.7.a: Selection equations

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
Size	0.049***	0.003	0.069***	0.003
Age	0.406***	0.010	0.405***	0.010
Dividend	0.039***	0.002	0.038***	0.002
St. leverage	0.671***	0.052	0.485***	0.061
Lt. leverage	0.510***	0.044	0.456***	0.043
Tobin's Q	-0.055***	0.004	-0.063***	0.005
Int.cov.ratio	0.124***	0.015	0.093***	0.015
Fin.slack	0.041	0.047	-0.181***	0.047
Pr.efficiency	0.183***	0.056	0.166***	0.057
Tangibility	2.791***	0.023	1.629***	0.023
Constant	-1.158***	0.050	-1.001***	0.052
Model p-values		0.000		0.000

Table 3.7 continues on next page.

Table 3.7.b: Investment equations

Two separate investment equations for each of the models demonstrate how different the firms' investment behavior across the two regimes. The investment equations are estimated with sector and year dummies and clustering by company ID is used to correct the error structure of the estimations.

	Model 1		Model 2	
	coeff	std.er	coeff	std.er
	Unconstrained			
Cash flow	0.184***	0.030	0.144***	0.032
Cash flow*Pr.efficiency	0.307***	0.047	0.387***	0.045
Cash flow*Tangibility			0.238***	0.074
Fin.slack	0.114***	0.014	0.032**	0.014
Tobin's Q	0.011***	0.002	0.008***	0.002
Pr.efficiency	-0.340***	0.028	-0.388***	0.027
Tangibility			-0.198***	0.009
Constant	0.463***	0.029	0.554***	0.024
	Constrained			
Cash flow	0.300***	0.050	0.323***	0.057
Cash flow*Pr.efficiency	-0.077	0.077	-0.226***	0.079
Cash flow*Tangibility			0.232*	0.130
Fin.slack	0.241***	0.021	0.173***	0.022
Tobin's Q	0.003	0.002	0.001	0.002
Pr.efficiency	-0.526***	0.055	-0.509***	0.058
Tangibility			-0.274***	0.034
Constant	0.562***	0.065	1.180***	0.052

As explained earlier, the ***switchr*** package for estimating our switching regression models needs to be provided with an initial guess for the classification variable for every model. Initially we model this initial guess by sorting out all observations with predicted efficiencies above the 50th percentile value as financially unconstrained. ***Switchr*** calculates it's own classification vector based on the variables comprising the Z vector of equation 3.10 to estimate the two regime specific investment equations. Later 60th, 70th and 80th percentile values are used as the initial cut-off points, but the results are not found to be sensitive to these changes at all. This confirms that the two regimes are indeed endogenously selected by the model, no matter how we create the initial exogenous classification.

3.7 Conclusion

This chapter provides a distinctive complement to the existing literature by suggesting new ways to study the impact of capital market imperfections on investment decisions of individual firms. Using an unbalanced panel data on 1122 UK firms listed on the London Stock Exchange during the period 1981 to 2009, we estimate endogenous switching regression models incorporating our predicted corporate efficiencies from the stochastic frontier analysis in our effort to confront the major challenges in this line of studies. Our selection equation reveals that firms that are larger, older, have lower market-to-book ratio, have lower financial slack, pay high dividends and have more tangible assets are more likely to operate in the unconstrained regime. Firms with high level of external debt are associated with a lack of financial constraints. Financially constrained firm's investment is more sensitive to both measures of internal liquidity (i.e., cash flow and financial slack) which points to the imperfect substitutability between internal and external source of finance. Most importantly, firm's efficiency has significant effect on the credit status of the firms as their access to external financing eases with the improvement of efficiency. Our findings suggest a non monotonic effect of corporate efficiency on cash flow sensitivities which is found to be decreasing for financially constrained firms as opposed to increasing for the unconstrained ones and such contrasting behavior may be explicated by the revenue and cost effect. This provides important evidence in resolving the controversial role of cash flow in detecting the presence of capital market imperfections and provides a different resolution to the highly debated Fazzari et al. (1988) and Kaplan and Zingales (1997) issues. If the comparatively higher sensitivity of investments to the availability of internal funds for the financially constrained firms is solely generated because of the measurement error issue, then it shouldn't be decreasing with improvement in efficiency or agency cost. So, we argue that investment cash flow sensitivities can still be used to capture the effects of capital market frictions on firms' investment, at least for the financially constrained firms. Moreover, the results are free from the priori classification bias as these constrained firms are endogenously classified by our model.

Chapter 4

Financial constraints and the dynamics of firm size and growth

4.1 Introduction

Building on the idea that internal and external finance becomes imperfect substitute of each other under the presence of market imperfections, most of the theoretical and empirical studies investigate the effect of financing constraints on firms' investment decisions. The results show relatively higher sensitivity of investment to internally generated funds for firms which are likely to be more severely affected by these market imperfection problems, hence are financially constrained. Chapter three of this thesis is not an exception where we agree with Fazzari et al. (1988) that the cashflow sensitivity is a useful indicator for the relative importance of financing problems across different groups of firms after taking into account the critiques of this approach. Following this strand of literature, empirical studies investigating the effect of financing constraints on firm growth have recently started to flourish as well. Most of these studies start with Gibrat (1931) "Law of Proportionate Effects" (LPE) as an empirical benchmark, which states that the growth rate of any firm is independent of it's size at the beginning of the period examined and that the firm size distribution (FSD) is stable over time and approximately log normal. A large body of empirical studies challenge three main implications of this law while working on it's further implications upon industrial organization. Firstly, firm size distribution (FSD) often displays shapes diverse from the lognormal. Secondly, both growth and volatility of growth at the firm level decrease with firm size and age, generating heteroskedasticity in firm size and growth distribution. Finally, firm growth rates often display a fat-tailed empirical distribution which cannot be easily explained if growth shocks to firms are assumed to be identically and independently distributed. An extensive survey of 60 papers made by Santarelli et al. (2006) concludes that evidence is rather mixed and it is not possible either to generally validate or systematically reject this law.[12] However, Stam (2010) express that Gibrat's Law still plays a remark-

[12]The robustness of the existing evidence favoring or rejecting a LPE type of dynamics has been questioned on three specific grounds. Firstly, if investigations of firm growth and size dynamics are carried out using aggregated data covering a large collection of heterogenous firms, then LPE may hold simply because of the aggregation of persistently heterogeneous firm dynamics (Bottazzi and Secchi, 2003). Secondly, the first two implications of the law may depend to a certain extent on sample selection as well. Evans (1987b), Hall (1987), Cabral and Mata (2003) assert that, the independence hypothesis is accepted when investigation is carried with a sample of certain sectors or size classes only, but may be rejected otherwise.

able and prominent role in the progress made by most recent studies involving firm growth.

Based on this set of findings on the size-growth relationships, recent papers propose an explanation for this behavior of the FSD based on financing constraints after it has been clarified that the departure from the LPE cannot be entirely explained by firms' age. In particular, Cooley and Quadrini (2001), Cabral and Mata (2003) and Desai et al. (2003) argue that the presence of financial constraints can account for the observed skewness in the firm size distribution and firm size distribution becomes more symmetric as financial constraints eases up. In contrast, studies by Fagiolo and Luzzi (2006) and Angelini and Generale (2008) fail to affirm that financial constraints are the main determinant of FSD evolution. In a different approach, Carpenter and Petersen (2002) employ the internal finance theory of growth to help explain the stylized facts of firm growth. They also rely on the Fazzari et al. (1988) approach, but switched to investigating how possible finance constraints could affect the growth of total assets instead of investment in fixed capital only. Thus, their test on the relevance of finance constraints uses the same principle as that applied to investment models: higher growth-cash flow sensitivities are a sign of bigger financing problems. They prefer to examine the growth of the whole firm as it allows controlling firm's all potential uses of internal finance and it helps to make a quantitative prediction about the relationship between internal finance and growth in contrast to the qualitative predictions usually made with the investment cash flow sensitivity. They prescribe this quantitative prediction as a stronger test for the existence of financing constraints as it is more likely to be unbiased from measurement error problem of investment opportunities, more restrictive and allows fewer alternative interpretations of the results.[13] Therefore, their methodological approach

And finally, if panel data regressions investigating the growth-size relationships are carried on without controlling for other determinants of firm growth and size dynamics, such as financial factors (Becchetti and Trovato, 2002).

[13] It can be recalled here from the literature review section of chapter three that, if the Hayashi (1982) conditions are not satisfied or if investment opportunity is not properly measured, a positive investment cash flow sensitivity may still be generated by a regression which not necessarily indicate the presence of financing constraints. According to Carpenter and Petersen (2002), their suggested quantitative prediction are unlikely to be affected by the bias from an omitted variable or mismeasured investment opportunities and any alternative explanations

gives a different resolution to the highly debated issue of detecting the presence of financial constraints.

The model developed by Carpenter and Petersen (2002) further predicts that a small firm facing a binding financing constraint may generate more than a one to one relationship between internal finance and the growth of it's assets through "leverage effect" which occurs when firm's access to debt depends on collateral. Bernanke et al. (1999) explain this leverage effect through their model which shows that each firm's capital expenditures are proportional to the net worth of the owner or entrepreneur and the proportionality factor is positively related to the expected discounted return to capital or external finance premium. For financially constrained firms, a rise in this expected discounted return to capital induce entrepreneurs to finance more of their capital investment out of their net worth and the expected default probability will reduce as a result. Also, a rise in net worth for a given project size can be considered as a rise in their collateral value and hence can give a positive signal to the lenders about future prospects of these firms in situations with asymmetric information. These will require less monitoring from the lenders and reduce the required premium on external finance. As a result, these firms will be able to take on more debt to expand the size of the firm and enjoy a magnified effect of a positive income shock on growth (Gilchrist and Zakrajsek, 1995). The graphical presentation of this leverage effect by Carpenter and Petersen (2002) is given as figure C.1 in appendix C (p. 167) of this thesis. When firms' access to external financing become easier or firms become less financially constrained, their new assets can be easily financed by new debt or equity along with their undistributed retained earnings. Therefore, growth is expected to become less sensitive to internally generated funds or net worth and the relationship between internal finance and growth should become much weaker. Later, this model is followed by Oliveira and Fortunato (2006) for Portugal, Hutchinson and Xavier (2006) for Belgium and Slovenia, Fagiolo and Luzzi (2006) for Italy and Wagenvoort (2003) and Coluzzi et al. (2012) for Europe.

of their results accounting for such bias would generate the same quantitative predictions that their model generates.

A major problem affecting almost all these investigations arises from the fact that financial constraints are not directly observable. To overcome this issue, this strand of literature follows the conventional way of classifying financially constrained and unconstrained firms a priori using proxies such as size or age of the firm in order to estimate the sensitivity of a firm's growth rate to it's cash flow. They implicitly assume that firms' records with respect to the chosen proxy determine the lenders' willingness to grant credit to them. Introducing financial constraints within the framework of firm growth dynamics may also create a new problem. This is because, firms' size and age used to identify financial constraints, are themselves related to the FSD independently of their effect through financial constraints. Angelini and Generale (2008) use an alternative survey based measure of financial constraints where firms are asked to give a self-assessment of the difficulty they face to access financing from banks or other institutions. However, such survey based measures can also suffer from misreporting and sample selection bias, whose effect is difficult to quantify. Moreover, such measures only take account of the demand side of credit relations by collecting the opinion of the credit seeker about their own financing conditions. But, practically the opinion of the credit supplier on the credit seeker plays the crucial role in determining credit conditions in capital market suffering from strong informational asymmetries.[14]

This chapter attempts to tackle this issue by using the outcomes from previous two empirical chapters of this thesis. The main motivation of using switching regression model in chapter three was to overcome the static and dynamic misclassification problem associated with this issue, but will not be suitable for estimating dynamic growth equations as they are expected to suffer from dynamic panel bias and give inconsistent results. These are explained in more details in the methodology section. But, one additional benefit of using the switching regression model is that it predicts the probability of facing unconstrained financial status. This is a single time varying and continuous indicator of financial sta-

[14] Angelini and Generale (2008) themselves admit the criticisms of the survey based measures of financial constraints and use alternative balance sheet based proxies to check robustness of their results.

tus for all firm year observations, accounts for the different degree of difficulty a firm faces in accessing external finance and generated from a multivariate selection equation which simultaneously considers all possible aspects of firm financial structure used in the literature. All these are prescribed as necessary features to be a good financial constraint proxy (Cleary, 1999, Lamont et al., 2001). This index is mainly used in this chapter to classify financially constrained and unconstrained status.[15] Apart from that, the predicted corporate efficiency index from chapter two is used as well to serve the same purpose. According to theoretical background, this predicted efficiency originates from managerial routine and can affect firms' technical capabilities, organizational characteristics and overall competence. All these are likely to affect firms' recognition as a borrower and thus set their financial constraint status as well. The selection equation of the switching regression model in chapter three also strongly suggests that a firm's constrained credit status improves with the level of it's corporate efficiency.[16]

Therefore, the empirical strategy in this chapter employs the financing constraint literature to explain whether the heterogeneity in firms' growth can be explained by the degree of financial constraints they face by developing the Carpenter and Petersen (2002) model. Even though such analysis is done by Wagenvoort (2003) and Coluzzi et al. (2012) for Europe, this is the first time UK data has been used. The complex interactions of size, age and financial constraints within the framework of an augmented Gibrat's regression to determine growth dynamics of firms is going to be the main contribution of this chapter. On the way to achieve that, our two novel proxies for financial constraints allow us to make quantitative assessment of the extent to which different degrees of financial constraints are interlinked with these interactions. To do this, the cash flow variable is interacted with different category financial constraint dummy variables created using the unique proxies for financial constraint status, rather than splitting the sample based on firm size or age. This specification is another improvement

[15]More detailed explanations and properties of this index are given in page 99 of this thesis. Here, we will use the index calculated from model 2 of table 3.2 (p. 94) as that was our final model.

[16]More detailed explanation and properties of this index are given in page 53 of this thesis. Here, we will only use the long run efficiency calculated from the second market value frontier model of table 2.2 (p. 51) considering it's relative advantage in better business evaluation.

from the contemporary studies in this field which allows the estimated cash flow coefficient to differ across observations in the different financial constraint categories without estimating the equations on separate sub-samples of firms. This approach can help to avoid problems of endogenous sample selection,[17] to gain degrees of freedom besides allowing transition between groups (Carpenter and Guariglia, 2008, Guariglia, 2008). Finally, we use system-GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) because of it's considerable advantages over simple cross-section regressions or other estimation methods for dynamic panel data according to a growing consensus in the context of empirical growth models (Bond et al., 2001). This estimation procedure controls for the presence of unobserved firm-specific effects that can be correlated with the firm growth rate and with the explanatory variables and hence avoids the bias that arises in this context. This also allows parameters to be estimated consistently in models that include endogenous right-hand side variables, for example cash flow in this case. Using the unbalanced panel of 1122 firms listed on London stock exchange during the period 1981-2009, we estimate our dynamic regression models to check the following key hypothesis:

1. Smaller firms grow more after controlling for liquidity constraints.
2. Younger firms grow more after controlling for liquidity constraints and firm size.
3. Liquidity constraints negatively affect growth after controlling for size and age.
4. The effect of liquidity constraints on firm growth differs according to the degree of financial constraint.

The rest of this chapter is structured into different sections as follows. Section 4.2 draws literature survey, section 4.3 describes the methodology, section

[17]Truncating the data based on some proxy for financial constraints are suspected to give biased and inconsistent estimates for our parameter of interest as these proxies are likely to be correlated with growth (Hausman and Wise, 1977).

4.4 brings model specification and description of the variables, section 4.5 introduces data and descriptive statistics, section 4.6 presents the empirical results and analysis and finally section 4.7 concludes the chapter.

4.2 Literature review

We previously discussed the investment and financing constraint literature in chapter three. To study the relationship between financing constraints and firm growth and to explain the dynamics of firm growth, we make use of that corporate finance literature in this chapter in combination with the industrial economics literature. Since Gibrat (1931)'s seminal study, the patterns of firm growth and their implications for the observed firm size distribution have been studied both from a theoretical and an empirical perspective by several authors and the evidence provided by them is rather mixed. Overall, the recent research trying to establish a link between financial constraints and firm dynamics, has developed into two interrelated directions. One of them highlights the possible role played by age and financial constraints in determining the observed skewness in the aggregate firm size distribution. The other one focuses on estimating the standard Gibrat's regressions of growth on size, age and various financial variables to test the LPE "null hypothesis" and it's further implications upon industrial organization.

4.2.1 Skewness in the firm size distribution

Studies working with a particular class of firms in the economy which are generally large enough to overcome the minimum efficiency scale of a given industry, mostly support the Gibrat's law.[18] But the law is generally found to be violated when firms of all sizes, sectors and industries are taken into account. Researchers moving away from the growth size independence towards a negative dependence of growth rates on size, suggest that the distribution of firm size may evolve over time and differ from a lognormal distribution. The majority of the studies observe

[18] Simon and Bonini (1958) and Mowery (1983) for USA, Hart and Oulton (1996) for UK, Becchetti and Trovato (2002) for Italy, Geroski and Gugler (2004) for Europe.

firm age to have a negative influence on it's growth as well. Such a negative age growth relationship is explained theoretically by Jovanovic (1982) who highlight the role of learning in explaining the firm size dynamics. Their model assumes that output is an increasing concave function of managerial efficiency and firms can discover their true efficiencies only when they decide to enter and operate in an industry. It is more likely that an old, large operating firm has already made a series of positive discoveries about it's true efficiency, leaving less scope for further efficiency gains from learning. Whereas, a young firm is more probable to make positive discoveries about it's true efficiency which encourages it to invest more rapidly in order to close the gap between it's start-up size and the minimum efficient scale (MES) and thus experiences higher growth rates immediately after start-up. Such negative age-growth relationship has been found empirically for different countries.[19]

Further investigations of the effect of age on growth include financial constraints as a potential and significant factor affecting firm size distribution. According to the theoretical explanation given by Cooley and Quadrini (2001), firms' technological differences in the presence of financial market frictions can be one reason behind the negative age growth relationship. They show that capital constraints can potentially explain why small firms pay lower dividends, are more highly levered, have higher Tobin's Q, invest more, and have investments that are more sensitive to cash flows. Using a large sample of Portuguese manufacturing firms, Cabral and Mata (2003) find that the firm size distribution can be well approximated by a log-normal distribution as firm age increases, but remains highly skewed to the right at birth when they are more likely to be capital rationed. Using a theoretical model, they further show that financial constraints can explain such FSD evolution which is supported by empirical evidence as well. They argue that financial constraints tend to weaken over time so that firms are allowed to raise the resources to invest and reach their optimal size which gives rise to a more symmetric size distribution in turn. Other than these, some of the newly

[19] Evans (1987a,b); Dunne et al. (1989) for US; Dunne and Hughes (1994) and Rahman (2011) for UK; Kamshad (1994) for France; Farias and Moreno (2000) for Spain; Becchetti and Trovato (2002) for Italy.

entrant firms can remain small because they are reluctant to grow because of efficiency grounds, even if they are not severely capital constrained. Considering the roles of the institutional environment and capital constraints on entrepreneurial activity across Europe, Desai et al. (2003) also observe the skewness in the size distribution of European firms which is also found to be decreasing with firm age. Comparing the overall distribution of firm size between Western Europe and Central and Eastern Europe, they conclude that the firm size distribution is more highly skewed for Central and Eastern Europe than Western Europe. When they perform a similar analysis for Great Britain only, the overall distribution is found to be much less skewed which they suggest is due to Britain's highly developed capital market.

Using data on Italian manufacturing firms, Fagiolo and Luzzi (2006) find that the negative impact of firm size on growth worsens with the severity of liquidity constraints and the magnitude of the size-growth correlation decreases substantially over time for any level of internal liquidity. Their findings concur with Cooley and Quadrini (2001) in that presence of financial constraints can explain the negative association between firm age and growth. However, their FSD remains positively skewed over time contradicting with Cabral and Mata (2003). Using non parametric estimates for Italian firms, Angelini and Generale (2008) also find skewness in firm size distribution, but diminishing with age supporting Cabral and Mata (2003). They test whether the firm size distributions for constrained firms are different from those for the unconstrained ones, where firms are classified using a survey based proxy of financial constraints. Their results suggest that financial constraints cannot be the main determinant of the FSD evolution for financially developed economies, even though financial constraints problems are likely to be more severe among younger firms. Lotti and Santarelli (2004), Cirillo (2010) also support the positive skewness in the firm size distribution of Italian firms. Size distribution is found to vary appreciably with the firms' age but remain fairly stable over time for every age class and different industries are found to display different paths and speeds of convergence toward the limit distribution.

4.2.2 Gibrat's regression

Simple empirical investigations of Gibrat's law rely on estimation of equations where current firm size is defined as a function of initial firm size. Sometimes, the equation is altered slightly to present firm growth as a function of initial firm size and can be augmented by other factors related to firm growth and the researchers focus on the estimated coefficient of the initial firm size. If firm growth is independent of size, then it takes the value of zero. If it is greater than zero, then larger firms grow more rapidly leading to concentration and monopoly. If it is smaller than zero, then smaller firms grow faster than their larger counterparts. The last result is frequently labeled as reversion to the mean size and is evident in the majority of the studies. Through the inclusion of additional variables like cash flow as a proxy for liquidity constraints to the LPE regression, researchers interpret high growth-cash flow sensitivities as an indicator of firms' excessive dependence on internal funds to finance new investment projects. Therefore, growth of these firms will be restricted by the profit generating capacity of their existing production facilities.

One of the influential studies to investigate the effect of finance constraints on overall firm growth, Carpenter and Petersen (2002) necessitate the inclusion of cash flow in a growth regression to show higher growth-cash flow sensitivities as a sign of bigger financing problems. They give similar reasoning as Fazzari et al. (1988), but prefer to examine the effect on firm growth rather than on investment in fixed assets. This is because investment in fixed assets covers only one part of the use of a firm's internal finance, failing to take into account of their alternative usage in production, cash holdings, late payments etc. Therefore, they propose to measure the growth rate by the relative change in firms' total assets which will capture not only firms' growth in physical capital, but also gross working capital. They apply standard first differenced regression along with an instrumental variable procedure using an unbalanced panel data set of 1,600 small quoted firms in the United States. Their estimates are on three subgroups of the data defined by their use of external equity finance. The results reveal that the relationship between growth and cash flow is higher than one because of the leverage effect for firms that make no use of external equity which indicates a binding financing constraint for these firms. On the contrary, firms that have easy access to external equity face a more relaxed financial constraint which makes their growth-cash flow sensitivity much weaker. Even though Carpenter and Petersen (2002) do not incorporate the Gibrat's framework in their regressions, they use their internal finance theory to explain some stylized facts regarding the law.

Wagenvoort (2003) estimate a similar model for different size classes of firms of the EU countries adding the impact of leverage and firm size to their empirical analysis and supports the same conclusion that growth-cash flow sensitivities decrease as firms become less financially constrained. He further split the sample into quoted and unquoted companies and finds that unquoted firms face higher growth cash flow sensitivities than quoted firms and the difference is especially pronounced for small firms. He argues that outside investors do not have proper information regarding these firms which makes them capital rationed and their growth determined by the availability of internal funding to a great extent. Hutchinson and Xavier (2006) also prefer to make quantitative comparison of the level of internal finance constraints on the growth of SMEs in the manufacturing sector between Slovenia and Belgium using the GMM-difference estimator developed by Arellano and Bond (1991) and according to their findings, the growth of Slovenian firms are more sensitive to internal finance than their Belgian counterparts. They also find that young firms and firms with longterm debt are most constrained and micro and SME firms[20] face great difficulties in accessing external sources of finance. Using European data as well, Coluzzi et al. (2012) choose to test an augmented version of the LPE by including size, past growth and a direct measure of financial obstacles obtained from survey data to the Carpenter and Petersen (2002) model. They estimate the determinants of financial obstacles first and then use the estimated coefficients to compute the predicted probability of facing financial obstacles for a firm. They apply the GMM-system estimator developed by Arellano and Bover (1995), and Blundell and Bond (1998) to esti-

[20]They apply the definition of firm size proposed by European Commission; Micro-firms: employee < 10 & realturnover < 2 million euors; SME firms: employee < 250 & realturnover < 50 million; Large firms: employees ≥ 250 & realturnover ≥ 50 million.

mate their dynamic LPE equation and find that their proxy for financial obstacles negatively affects firm growth and the impact appears to be comparatively larger in those countries having larger shares of SMEs in the sample. They also find firms' growth responding positively to cash flow, which means that firms' growth are hampered by liquidity constraints and this is likely to be linked with the existence of financial obstacles.

Motivated by the same idea of using liquidity constraints to explain the firm size growth dynamics, Fagiolo and Luzzi (2006) show on 14,277 (surviving) Italian manufacturing firms from 1995 to 2000 that younger and smaller firms grow more, but their growth significantly suffer from the liquidity constraints. Moreover, they find that the negative impact of size on growth increases in magnitude as liquidity constraints become more severe. They perform a standard Gibrat's type regression as well, but rely on employment growth rather than total assets growth. Oliveira and Fortunato (2006) also analyze employment growth using a large unbalanced panel data set of 7653 Portuguese manufacturing firms surviving over the period from 1990 to 2001 in their effort to explain the relationship between firm size and growth by financial constraints. Their standard Gibrat type model specification also incorporated lagged growth as an additional regressor for addressing persistence of chance or serial correlation on firm growth. Following the conventional method, they split their sample by firm size and age as it is expected that different size and age categories of firms may face different degree of financial constraints and estimate separate regression for the full, small, medium, large, young and old firms using the GMM-system estimator. Their overall results reject Gibrat's law of proportionate effect and suggest that the growth of small and young Portuguese firms are more finance constrained compared to their large and old counterparts. In another of their papers published later, they investigate similar issues with 419 surviving services firms in Portugal during the period from 1995 to 2001. Using the same estimator, they conclude that negative size-growth and age-growth relationship exists for services too and size, age along with past growth mostly explains the growth of firms (Oliveira and Fortunato, 2008).

Angelini and Generale (2008) also apply the system GMM estimator to assess the relationship between financial constraints and employment growth using two datasets of Italian firms. They use both a direct measure of financial constraints from the survey data and interest coverage and asset tangibility as alternative balanced sheet based proxies for financial constraints. Using all these different measures separately, they create dummy variables taking zero-one to differentiate financially constrained and unconstrained firms. Their results suggest that financial constraints in a given year negatively and significantly affects firm growth in that year and this effect is valid for small constrained firms, but not for young constrained ones. Furthermore, more profitable firms are found to grow faster and older firms to grow slower. Rahman (2011) provides evidence that effects of various sources of financing (i.e., internal funds, bank credit facility) on firm employment growth are statistically significant and quantitatively important using 5214 private and publicly incorporated and surviving firms in the UK and Ireland during the period of 1991-2001. He stratifies the sample into small, medium and large firms using the year 1991 employment as the initial size of the firm and estimates separate regression for these subgroups and also for the quoted and unquoted samples within each of these groups. He focuses on a firm's access to a bank credit facility as a measure of external financing constraints following Sufi (2009). His results using the GMM-difference estimator show that the incremental effect of internal financing on firm growth decreases with alleviation of the external financing constraints and as a result firms switch to external financing sources as their primary source of financing for growth and such a pattern of transition is particularly pronounced in small unquoted firms. His results further show that higher leverage and a better governance structure has a favorable effect and firms' size and age has a negative effect on firm growth.

From a slightly different approach by using revenue growth, Huynh and Petrunia (2010) investigate the relationship between different financial factors (i.e., leverage, initial financial size) and firm growth particularly focusing on the hypothesis that age effect occurs because of financial factors using 19233 Canadian manufacturing firms during 1985 to 1997. Further, they use an interaction of leverage with leverage quintile dummy variables to account for any non-linearity in the growth leverage relationship. Their overall result using the GMM-system estimator reveals a positive and nonlinear relationship between leverage and firm growth where the sensitivity of growth to leverage is highest for firms in the lowest to intermediate leverage quintiles. A non-monotonic U-shaped relationship between firm growth and age and a positive relationship between current growth and firm's initial financial size is also observed.

All the above papers mention some common problems with estimating growth equations due to endogenous explanatory variables and time invariant firm specific effects and propose different ways to tackle these problems. In this chapter, we will mainly follow the spirit of Carpenter and Petersen (2002) and Oliveira and Fortunato (2006) and will potentially try to make some contribution and improvement through our model specification to give some different insights in the firm size-growth relationship.

4.3 Methodology

Starting with a simple AR (1) specification of firm size with unobserved firm-specific effects η_i and year specific effects τ_t respectively,

$$size_{i,t} = \alpha size_{i,t-1} + \eta_i + \tau_t + \nu_{i,t} \tag{4.1}$$

Where, size is in natural logarithm form, $E[\eta_i] = 0, E[\nu_{i,t}] = 0, E[\eta_i \nu_{i,t}] = 0$ for i = 1,......, N firms and t = 2,.....T years.

Also, it is assumed that errors $\nu_{i,t}$ are serially uncorrelated and that the initial conditions $size_{i1}$ are predetermined. That is, $E[\nu_{it}\nu_{is}] = 0$ for i=1,.......,N and $s \neq t$ and $E[size_{i1}\nu_{it}] = 0$ for i = 1,......, N firms, t = 2,.....T years.

Subtracting $size_{i,t-1}$ from both sides,

$$size_{i,t} - size_{i,t-1} = \alpha size_{i,t-1} - size_{i,t-1} + \eta_i + \tau_t + \nu_{i,t} \tag{4.2}$$

$$growth_{i,t} = (\alpha - 1)size_{i,t-1} + \eta_i + \tau_t + \nu_{i,t} \tag{4.3}$$

Equation (4.3) is equivalent to (4.1) and can be considered either as a model for level or growth. Equation (4.3) can be augmented by a set exogenous or endogenous variables controlling for different firm characteristics, $X_{i,t}$.

$$growth_{i,t} = (\alpha - 1)size_{i,t-1} + \beta X'_{i,t} + \eta_i + \tau_t + \nu_{i,t} \tag{4.4}$$

In estimating the firm growth equation, some researchers include lagged growth to check for growth persistency. However, the results are quite mixed and conflicting as positive, negative and insignificant persistency has often been reported (Caves, 1998, Coad, 2007). We do not include lagged growth due to the presence of inactive firms in our panel because it is not possible to analyze the persistence of growth for firms that leave the industry during the observation period (Santarelli et al., 2006). Estimating such a dynamic regression model of firm growth controlling for different possible determinants on a panel of heterogeneous firms may raise several econometric problems (Roodman, 2009a, Bond et al., 2001):

- Omitted variable or time-invariant firm characteristics (fixed effects) η_i may be correlated with the explanatory variables and cause biased estimation.
- The idiosyncratic disturbances $\nu_{i,t}$ may have individual-specific patterns of heteroskedasticity.
- Due to the shorter time and larger firm dimension of the panel data, a shock to the firm's fixed effect may not dissipate with time and hence cause significant correlation of the $size_{i,t-1}$ with the error term.
- Apart from $size_{i,t-1}$, some other regressors may be endogenous and thus may be correlated with the error term in the regression.

All these problems make OLS and the within estimator biased and inconsistent. As $size_{i,t-1}$ is endogenous to the fixed effects, OLS gives rise to "dynamic panel bias" (Nickell, 1981). The within group estimator removes the fixed effect, but may still suffer from dynamic panel bias (Roodman, 2009a). Baltagi (2005) emphasizes that only if $T \rightarrow \infty$, the within estimator can be consistent. But, the bias can be as much as 20% of the true coefficient of interest even for T=30. Another way to tackle these problems is to use first differenced GMM estimator (Arellano and Bond, 1991), which is basically taking the first differences of the equation to remove the time invariant effects and instrument the endogenous explanatory variables using levels of the series lagged two periods or more, under the assumption that the time-varying disturbances in the original levels equation are serially uncorrelated.

But that is also suspected to suffer from serious finite sample biases when the time series from short panels are even moderately persistent making the available instruments weak (Blundell and Bond, 1998, 2000, Bond et al., 2001, Bond, 2002). The presence of serious finite sample biases can be detected by comparing the first-differenced GMM results to alternative estimates of the autoregressive parameter α in equation 4.1 or equivalently $(\alpha - 1)$ in equation 4.3. It is well established in the literature that in the AR(1) specification like equation 4.3, OLS gives an estimated co-efficient of $(\alpha - 1)$ which is biased upwards in the presence of individual specific effects. FE gives the estimated co-efficient of $(\alpha - 1)$ which can be seriously biased downward. This suggests that a consistent estimate of $(\alpha - 1)$ should lie in between the OLS levels and within groups estimates. If the estimated coefficient of $(\alpha - 1)$ by difference GMM is close to FE estimates or lower than that, then that is also suspected to be biased downwards due to weak instruments. This is expected to happen when there is persistency in the series, or $\alpha \rightarrow 1$, and when the variance of the individual effects η_i increases relative to that of the $\nu_{i,t}$.

In such a case, more reasonable and preferred results are shown to be achieved by using a system GMM estimator which exploits an assumption about the initial conditions to obtain additional moment conditions that remain informative even for highly persistent series. In system GMM, a system of equations in both first differences and levels are estimated, where the instruments used in the levels equation are lagged first differences and instruments used in the first differenced equation are lagged levels of the series. Although the levels of the dependent variable are correlated with the individual specific effect, the first differenced dependent variable is not which permits lagged first-differences to be used as instruments in the level equations. Blundell and Bond (1998) gives evidence from Monte Carlo simulations which shows that there can be dramatic reductions in finite sample bias and gains in precision from exploiting these additional moment conditions in system GMM estimators as compared with the first-differenced estimators.

A common conclusion about GMM estimators should be noted here that GMM estimators using the full set of moments available can be severely biased, especially when the instruments are weak and the number of moment conditions is large compared with N and that should be dealt with caution in estimating different model specifications. To avoid instrument proliferation, a mixture of restricting the lag structure and collapsing of the instruments can be applied as suggested by Roodman (2009b). The usual and reasonable test for two-step system GMM is the Hansen (1982) J-test because the older Sargan (1958) is not valid under heteroskedasticity. The Hansen J-statistics basically tests for the joint validity of the instruments used and the structural specification of the model. This statistic is asymptotically distributed as χ^2 with degrees of freedom equal to the number of overidentifying restrictions (i.e., the number of instruments less the number of estimated parameters). Under the null hypothesis, the instruments are orthogonal to the errors. In addition, no second order serial correlation (AR(2)) in the first difference of the disturbance term should be observed (Arellano and Bond, 1991) which checks the key identifying assumption that the level of the disturbances term are serially uncorrelated needed for some lagged instruments (i.e., $size_{i,t-2}$ and further lags) to be valid and GMM estimates to be consistent. Under the null hypothesis of no second-order serial correlation in the differenced residuals, the test asymptotically follows a standard normal distribution. The two step robust system GMM estimator uses corrected standard errors (Windmeijer, 2005) and makes the estimations more efficient and robust to any patterns of heteroskedasticity and autocorrelation within individuals (Roodman, 2009a).

Another concern may be the maximum T of 29 in our unbalanced panel data because the GMM estimators are mainly developed for panel data with small T and large N where the asymptotic statistical theory works by letting $N \to \infty$ and T fixed. The panel where T is also allowed to increase to infinity raises two sets of caveats according to the recent literature. One of them rejects the homogeneity of the regression parameters implicit in the use of a pooled regression model in favor of heterogeneous regressions and this relies on T being large enough to estimate separate regression for each groups. However, such heterogeneity in the parameters is particularly crucial in country, region or industry level analysis where T may not be too small as compared with N and there are fairly long time-series available for a large number of groups. Even though the maximum T is 29 in our panel, the number of firms survived for that long period is only few making the average T of our unbalanced panel to 9.6 only. And it has been shown that, the fixed T results for GMM remain valid when $T/N \to 0$ (Alvarez and Arellano, 2003). Another concern of having large T is non-stationarity, spurious regression and co-integration. The null hypothesis of unit root in all panels are tested by the Fisher unit root test for unbalanced panels for all the series we use in the model (results are reported in section 4.5).

4.4 Model specification

In the first stage, we estimate the following baseline dynamic regression model of firm growth.

$$\begin{aligned} Growth_{it} = {} & \beta_1 Size_{i,t-1} + \beta_2 Size^2_{i,t-1} + \beta_3 Age_{i,t} + \beta_4 Age^2_{i,t} \\ & + \beta_5 Cashflow_{i,t} + \beta_6 Tobin's\ Q_{i,t} + \eta_i + \tau_t + \nu_{i,t} \end{aligned} \tag{4.5}$$

The above model is then extended further as below to check the differential effects of cash flow on growth across firm years facing different degrees of financial constraints:

$$Growth_{it} = \beta_1 Size_{i,t-1} + \beta_2 Size^2_{i,t-1} + \beta_3 Age_{i,t} + \beta_4 Age^2_{i,t} + \sum_{k=1}^{n} \delta_k (dk_{it} * Cashflow_{i,t}) + \beta_6 Tobin's\ Q_{i,t} + \eta_i + \tau_t + \nu_{i,t} \qquad (4.6)$$

where, dk_{it} stands for two, three or five category financial constraints dummy variables as explained below.

4.4.1 Variables in the growth equation

Firm size and growth: In this chapter we use total assets as a proxy for firm size and growth in total assets as a proxy for overall firm growth in line with our model specification and also to make the quantitative predictions about the relationship between growth and internal finance as suggested by Carpenter and Petersen (2002). Firm size is calculated as natural logarithm of total assets and growth of firms is calculated as the difference in natural logarithm of total assets between two consecutive periods. Square terms of firm size is also included to check for the possible nonlinearity in the size-growth relationship following Audretsch and Elston (2006). However, as we have used sales as a proxy for firm size in chapter two and three, we will check the robustness of our results using sales as a proxy for firm size and growth in sales as a proxy for firm growth in the model. Rahman (2011) also use the logarithm of total assets and sales revenues interchangeably to control for size in his regression analysis, but only reports the regression results for the logarithm of total assets. Also, it could be mentioned here that there is no single best way to measure firm size and growth and the choice of the appropriate way of measuring firm growth depends on the research questions (Coad and Hölzl, 2010, Davidsson and Wiklund, 2006).

Age: A negative age growth relation is revealed in a number of empirical studies which conclude that young firms grow more rapidly. Similar to previous two chapters, natural logarithm of the number of years a firm appears in the chosen database is used as a proxy for firm age following Almeida and Campello (2007).

Cash flow: Cash flow is used as a standard proxy for firms' internal liquidity and it's inclusion will serve a twofold purpose. On one hand, this will potentially capture the impact of liquidity constraints on a firms growth. It is expected that the estimated coefficient on cash flow will be positive, which means firms with less liquidity problems will grow faster. On the other hand, this will also alow the actual relationship between firm size and growth to be determined keeping liquidity constraints constant. Keeping similarity with chapter three, we define cash flow as ratio of funds from operation to total assets following D'Espallier et al. (2008) and Carpenter and Petersen (2002).

Tobin's Q: Following the standard practice in the literature, Tobin's Q is included to control for a firm's investment opportunities. This controls for the fact that firms with good investment opportunities are likely to grow more rapidly than firms with comparatively limited investment opportunities. Controlling for investment opportunities also make sure that the growth-cash flow sensitivity can indicate the presence of financial market frictions only. Similar to that in previous chapters, it is calculated as the ratio of market value of assets to the book value of assets. Market value is estimated as book value of total assets minus book value of equity plus market capitalization and book value of total asset is simply value of total assets.

Financial constraint dummy: We will allow firms to transit between different financial constraint categories as it is discussed in chapter three that financially constrained firms can become financially unconstrained and vice versa. For this reason, we will conduct the empirical analysis based on firm-years rather than firms. Bond and Meghir (1994), Guariglia and Schiantarelli (1998), Carpenter and Guariglia (2008) and Guariglia (2008) adopt a similar approach in their studies. Therefore, the two category time varying dummy variables dk_{it} using the predicted likelihood of facing financially unconstrained status are constructed in the following way:

1. $Cd21_{it}$ is equal to 1 if firm i has a likelihood of facing financially unconstrained status in year t, which falls below the 50th percentile of the distribution of the corresponding likelihood of facing financially unconstrained status of all firm years, and equal to 0 otherwise.

2. $Cd22_{it}$ is equal to 1 if firm i has a likelihood of facing financially unconstrained status in year t, which falls above the 50th percentile of the distribution of the corresponding likelihood of facing financially unconstrained status of all firm years, and equal to 0 otherwise.

Here, it should be made clear that interacting cash flow with these two dummies in a single regression will not create any multicollinearity problem because $Cd21_{it} + Cd22_{it}$ will always be equal to 1. $Cd21_{it}$ will pick the cash flows of the likely financially constrained firm years and $Cd22_{it}$ will pick the cash flows of the likely financially unconstrained firm years and therefore, cash flow for a particular firm year will appear only once in the regression.

The three category variables $Cd31_{it}, Cd32_{it}$ *and* $Cd33_{it}$ are constructed in similar way by putting firm i with likelihood of facing financially unconstrained status in year t falling below the 25th percentile in first category, between 25th and 75th percentile in second category and above 75th percentile in the third category. And, finally the five category variables $Cd51_{it}, Cd52_{it}, Cd53_{it}, Cd54_{it}, Cd55_{it}$ are constructed by putting firm i with likelihood of facing financially unconstrained status in year t falling below the 20th percentile in first category, between 20th and 40th percentile in second category, between 40th and 60th percentile in third category, between 60th and 80th percentile in fourth category and above 80th percentile in the fifth category. Similarly, two, three or five category dummy variables Ed_{it} are created using the predicted corporate efficiency index from chapter two.

4.5 Data and descriptive statistics

We use the same data as in earlier chapters, collected from the Worldscope Global Database. We have an unbalanced panel of 1122 firms from thirty three different sectors from 1981 to 2009 with a minimum of three to a maximum of twenty nine consecutive years of observations and a total of 13183 firm-years. These thirty three sectors are differentiated according to FTSE/Dow Jones Industrial Classification Benchmark (ICB) codes. All financial variables are deflated with GDP deflator and all regression variables are winsored at the 1% and 99% level to get rid of the extreme outliers. Table 4.1 reports means and distributional information for all the regression variables used in this chapter.

Table 4.1: Descriptive Statistics

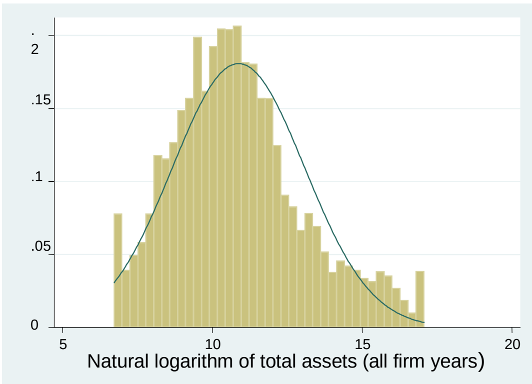
This table gives mean and distributional information for all the regression variables for which data is collected from the Worldscope Global Database for 1122 UK firms listed on the London Stock Exchange over the period 1981 to 2009. All financial variables are deflated with GDP deflator and all regression variables are winsored at the 1% and 99% level to get rid of the extreme outliers. Natural logarithm of total assets and natural logarithm of the number of years a firm appears in the database are used as proxies for firm size and firm age respectively. Growth of firms is calculated as the difference in natural logarithm of total assets between two consecutive periods. Cash flow is calculated as ratio of funds from operation to total assets. Tobin's Q is calculated as the ratio of market value of assets to the book value of assets. Market value is estimated as book value of total assets minus book value of equity plus market capitalization and book value of total asset is simply value of total assets.

	Mean	SD	Min	Q1	Median	Q3	Max
Size	11.35	2.280	6.722	9.681	11.14	12.82	17.07
Growth	.0761	.3759	-3.901	-.0648	.0388	.1707	3.967
Age	2.114	0.862	0	1.609	2.303	2.833	3.367
Cash flow	.0388	.2001	-1.015	.0198	.0836	.1345	.3385
Tobin Q	2.033	1.864	.5193	1.072	1.464	2.178	12.69

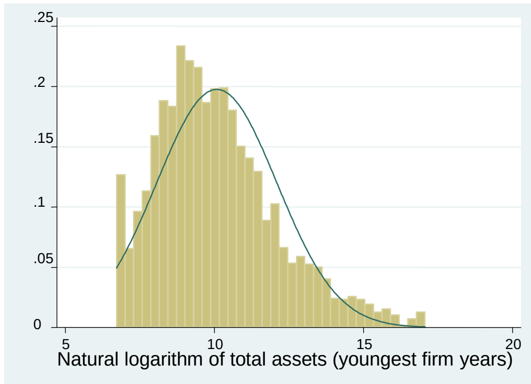
Here firm size is in natural logarithm of total assets, mean of which is 11.35. Figure 4.1 shows the pooled distribution of the logarithm of total assets of the sample firms with the superimposing normal distribution and as expected, the log transformation minimizes the positive skewness in the distribution of the level series (skewness of the level series is 13.48). Even after that, the firm size distri-

Figure 4.1: Firm size distributions

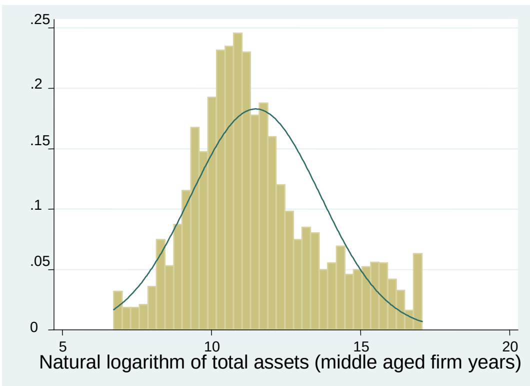
Figure (a) shows the pooled distributions of the logarithm of total assets of the sample firms. The distribution for the youngest firm years in (b) has the highest skewness, that for the middle aged firm years in (c) and the oldest firm years in (d) have lower skewness comparatively. The p-values of the Kolmogorov-Smirnov test reject the null hypothesis that firm size distributions of two age classes are equal.



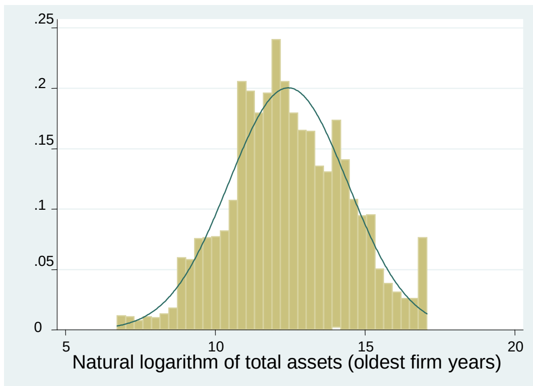
(a)



(b)



(c)



(d)

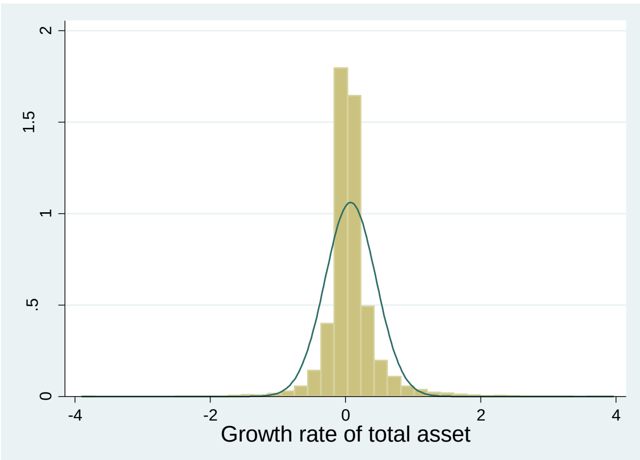
Kolmogorov-Smirnov tests for equality of distributions:
(b) = (c): p-value 0.000
(c) = (d): p-value 0.000

bution remains positively skewed and the skewness is highest for younger firms and decreasing thereafter with firm age and this confirms the stylized fact that firm size tends to increase with age. The null hypothesis of equality of the FSDs is strongly rejected for any two contiguous age classes using the Kolmogorov-Smirnov tests following Angelini and Generale (2008). The test results are reported in the figure.

Figure 4.2 shows distribution of pooled growth rate which is tent-shaped with tails fatter than those of a normal one. Most firms in the sample have a growth rate close to zero, while a small number of firms experience accelerated growth and decline. Coad and Hölzl (2010) confirm that such distribution of growth rates is a robust feature of firm growth process as it has been found in datasets from a number of countries, industries and years.

Figure 4.2: Firm growth distribution

This figure shows distribution of pooled growth rate which is tent-shaped with tails fatter than those of a normal one.



Null hypothesis of all panels contain unit roots against an alternative hypothesis that at least one panel is stationary for any series is tested using the Fisher-type test which does not require strongly balanced data and allows gaps within the individual series. The Fisher-type panel-data unit-root tests are based on the Augmented Dickey-Fuller (ADF) regressions which fits a model of the following form.

$$\Delta y_t = \alpha + \beta y_{t-1} + \zeta_1 \Delta y_{t-1} + \zeta_2 \Delta y_{t-2} + - - - + \zeta_k \Delta y_{t-k} + \epsilon_t \tag{4.7}$$

Testing $\beta = 0$ is equivalent to testing that y_t series follows a unit root process. The Fisher test first conducts unit-root tests individually for each panel included in the dataset, and then combines the p-values from these tests to produce an overall test. Z and L* statistics combine p-values using inverse normal and inverse logit transformations respectively. The p-values for these statistics strongly reject the null hypothesis for all the series we are using in this chapter (table 4.2). For the results reported in the table, we have allowed for drift and used k=1. However, the null hypothesis is rejected as well when we use lags 2 and 3.

Table 4.2: Fisher-type panel-data unit-root test

This table reports Fisher-type panel-data unit-root tests for the variables to be used. Z and L* statistics combine p-values using inverse normal and inverse logit transformations, respectively. The p-values for these statistics test the null hypothesis that all panels contain unit roots against an alternative hypothesis that at least one panel is stationary for the underlying series.

	Z	p-value	L*	p-value
Size	-29.96	0.000	-31.01	0.000
Growth	-53.04	0.000	-59.54	0.000
Age	-146.75	0.000	-286.63	0.000
Cash flow	-44.95	0.000	-48.19	0.000
Tobin Q	-47.85	0.000	-52.20	0.000

4.6 Empirical results

4.6.1 Presence of finite sample bias

The results of the simple AR(1) specification for the growth equation (equation 4.3) is presented in table 4.3. The four columns of the table report the results using OLS, within groups, difference-GMM and system-GMM estimators respectively. The results indicate that finite sample biases are present in this case. In particular, the estimated coefficient ($\alpha - 1 = -0.368$) of initial firm size in the first-differenced GMM results is lower than that in the within group estimates (-0.195) and hence is expected to be seriously biased downwards. The two step robust system GMM performs better in estimating the dynamic equation by keeping the estimated coefficient (-0.034) in between the OLS and within group estimates. Equation 4.1 and 4.3 are equivalent and so are their estimated results. The results for the level equation (equation 4.1) is presented in table C.1 of appendix C (p. 168).

Table 4.3.a reports p-values for the AR(2) and Hansen J statistics, number of instruments used, number of firms and firm years involved in the estimations. In both the difference and system-GMM estimations, only limited numbers of instruments are used. Out of the 31 and 32 instruments, there are two to four years lagged firm size for the differenced equation in both the estimators and one year lagged first differenced firm size for the level equation in the system GMM estimator and the rests are year dummies used as standard instruments. In both the cases, instruments are collapsed which creates one instrument for each variable and lag distance, rather than one for each period as well. These instruments are found to be jointly valid by the p-value of the estimated Hansen-J statistics. The Arellano-Bond AR(2) tests also do not provide any evidence for the presence of second-order serial correlation in first difference of the residuals which indicate that the instruments that we use in our estimations are appropriate. In estimating this particular model specification and all the others to follow, similar types instruments for similar model specifications are always used, so that the results are not driven by the choice of instruments.

Table 4.3: AR(1) specification with growth as dependent variable

This table shows the estimated results of equation 4.3 using OLS, FE, Difference and System GMM. OLS estimates include a full set of sector and year dummies as regressors, FE estimates include a full set of year dummies as regressors, GMM estimates include a full set of year dummies both as regressors and instruments. In addition to these, difference GMM estimates include L(2/4). size collapsed and system GMM estimates include L(2/4). size collapsed and DL(1/1). size collapsed as instruments for the difference and level equations respectively. Standard errors in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	OLS	FE	Diff-GMM	Sys-GMM
L.size	-0.019***	-0.195***	-0.368***	-0.034***
	(0.002)	(0.011)	(0.059)	(0.008)
Constant	0.393***	2.227***		0.337***
	(0.041)	(0.115)		(0.087)

Table 4.3.a: Diagnostics

The figures reported for the AR(2) and Hansen J tests are the p-values for their respective null hypotheses. AR(2) accepts the null hypothesis of no second-order serial correlation in the differenced residuals and Hansen J test accepts the null hypothesis that all instruments are jointly valid which implies that the instruments satisfy the required orthogonality conditions, i.e., their moments with the error term are zero.

	OLS	FE	Diff-GMM	Sys-GMM
AR(2) p-value			0.185	0.102
Hansen p-value			0.209	0.294
No of instruments			31	32
No of firms		1122	1122	1122
No of observations	11995	11995	10807	11995

Table 4.4 shows the results of the full augmented baseline model (4.5) using different estimators, OLS, FE, difference and system GMM in it's four columns which indicate the presence of finite sample biases in this case as well. The estimated coefficient of lagged firm size is biased in opposite direction in OLS and FE and the coefficient lies in between the two in the system-GMM. Table 4.4.a shows the relevant diagnostic tests. The strength of the p-value of the Hansen J statistics also hints that the additional first differenced instruments used in system-GMM estimation make the results more appropriate and consistent. Therefore, only two-step robust system GMM is used for estimating all model specifications later.

Table 4.4: Baseline equation using different estimators

This table shows the estimated results of equation 4.5 using OLS, FE, Difference and System GMM. OLS estimates include a full set of sector and year dummies as regressors, FE estimates include a full set of year dummies as regressors, GMM estimates include a full set of year dummies both as regressors and instruments. In addition to these, difference GMM estimates include lagged levels of size, age, cash flow and Tobin's Q as instruments for the first differenced equation and system GMM estimates include lagged levels and lagged first differences of size, age, cash flow and Tobin's Q as instruments for the differenced and the level equations respectively. Standard errors in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	OLS	FE	Diff-GMM	Sys-GMM
L.size	-0.236***	-0.681***	-0.528***	-0.341***
	(0.020)	(0.055)	(0.189)	(0.081)
L.size^2	0.009***	0.021***	0.010	0.013***
	(0.001)	(0.002)	(0.012)	(0.003)
Age	-0.157***	-0.255***	-0.226	-0.218***
	(0.027)	(0.071)	(0.194)	(0.060)
Age^2	0.024***	0.094***	0.147	0.039***
	(0.005)	(0.026)	(0.097)	(0.011)
Cash flow	0.796***	0.964***	0.736***	1.193***
	(0.029)	(0.044)	(0.269)	(0.116)
Tobin Q	0.006*	-0.024***	0.070**	0.118***
	(0.003)	(0.005)	(0.033)	(0.023)
Constant	1.913***	5.178***		2.130***
	(0.133)	(0.347)		(0.491)

Table 4.4.a: Diagnostics

The figures reported for the AR(2) and Hansen J tests are the p-values for their respective null hypotheses. AR(2) accepts the null hypothesis of no second-order serial correlation in the differenced residuals and Hansen J test accepts the null hypothesis that all instruments are jointly valid which implies that the instruments satisfy the required orthogonality conditions, i.e., their moments with the error term are zero.

	OLS	FE	Diff-GMM	Sys-GMM
AR(2) p-value			0.637	0.793
Hansen p-value			0.385	0.514
No of instruments			77	83
No of firms		1122	1122	1122
No of observations	11995	11995	10807	11995

4.6.2 Dynamics of size-growth relationship

Table 4.5 presents the twostep system GMM results of the baseline model (equation 4.5), where the explanatory variables are added sequentially in the four models according to the key propositions. In these estimations, firm size, cash flow and Tobin's Q are considered as endogenous and firm age is considered as pre-determined as described by the contemporary studies. All these variables are included as instruments, but distinctly for the level and difference equation (Oliveira and Fortunato, 2006, Angelini and Generale, 2008, Roodman, 2009a).

- M1. Law of proportionate effect which examines whether the growth rate of any firm is independent of it's size.
- M2. Adding cash flow to differentiate between the financial-related and sheer size effect on firm growth.
- M3. Adding firm age to see whether younger firms are growing faster than their older counterpart.
- M4. Adding Tobin's Q to control for investment opportunity so that the growth cash flow sensitivity can be seen as an indicator of the presence of financial constraints only.

Model 1 of table 4.5 shows that there are negative and significant size effects on growth present in the data. Therefore, small firms are inclined to grow faster than large firms. However, a positive and significant non-linear size effect is also found. Overall, the resulting size effect implies rejection of the Gibrat's law of proportionate effect, but the departure from the law subsides as the firm's size increases. This growth size relationship remains consistent in rest of the models. Besides testing the proportionate growth of a firm is independent of it's size, there are studies which investigate the LPE by testing whether the variability of growth is independent of size according to the second testable proposition of Tschoegl (1983). To examine the independence of growth variability of size for

Table 4.5: Twostep robust system GMM results for the baseline equation

This table shows the estimated results of equation 4.5 using twostep robust system GMM, where the explanatory variables are added sequentially according to the key propositions. In addition to the full set of year dummies both as regressors and standard instruments, the estimates include lagged levels and lagged first differences of size, age, cash flow and Tobin's Q as instruments for the difference and level equations respectively. Standard errors in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	M1	M2	M3	M4
L.size	-0.534***	-0.467***	-0.371***	-0.341***
	(0.137)	(0.094)	(0.063)	(0.081)
L.size^2	0.022***	0.018***	0.014***	0.013***
	(0.006)	(0.004)	(0.002)	(0.003)
Cash flow		1.045***	1.178***	1.193***
		(0.098)	(0.106)	(0.116)
Age			-0.269***	-0.218***
			(0.048)	(0.060)
Age^2			0.046***	0.039***
			(0.009)	(0.011)
Tobin Q				0.118***
				(0.023)
Constant	3.075***	2.898***	2.591***	2.130***
	(0.760)	(0.550)	(0.367)	(0.491)

Table 4.5.a: Diagnostics

The figures reported for the AR(2) and Hansen J tests are the p-values for their respective null hypotheses. AR(2) accepts the null hypothesis of no second-order serial correlation in the differenced residuals and Hansen J test accepts the null hypothesis that all instruments are jointly valid which implies that the instruments satisfy the required orthogonality conditions, i.e., their moments with the error term are zero.

	M1	M2	M3	M4
AR(2) p-value	0.106	0.203	0.188	0.793
Hansen p-value	0.331	0.319	0.324	.514
No of instruments	36	72	80	83
No of firms	1122	1122	1122	1122
No of observations	11995	11995	11995	11995

the firms in the panel, we estimate the following regression.

$$\sigma_{Growth_i} = \alpha_k + \alpha_2 \overline{Size_i} + \epsilon_i \tag{4.8}$$

where, σ_{Growth_i} represents the standard deviation of growth for firm i over t, $\overline{Size_i}$ represents the average size for firm i over t, α_k represents sector-level dummy variables and ϵ_i is a random disturbance term. For the full sample, the estimated size coefficient (α_2) is -0.0321, with a heteroskedasticity-consistent standard error of 0.0009. This rejects the independence of the variance of growth of firm size.

The comparison of model 1 and model 2 reveals that impact of only firm size on growth in model 1 may infact give a composite effect of "financial related" and "other" size effects as warned by Audretsch and Elston (2006). Model 2 exhibits similar size effects on growth even when liquidity constraints is controlled for, but as expected the magnitude of the size effect is reduced. Overall, liquidity constraints generate a negative, statistically significant effect on growth or in other words, firms with liquidity problems suffer from lower growth rates after separating out the size effect.

Model 3 of table 4.5 further suggests that younger firms experience higher growth rates after controlling for firm size and liquidity constraint. So, the negative age growth relation as predicted by Jovanovic (1982) is also present in our data. Overall, the relationship between firm growth and age is found non-monotonic U-shaped as described by number of earlier studies (Evans, 1987a,b, Huynh and Petrunia, 2010). Finally, we added Tobin's Q in model 4 to control for investment opportunity so that the observed growth cash flow sensitivity does not reflect that and can only indicate the presence of capital market imperfection following the similar practice we followed in chapter three. Even after including Tobin's Q, the growth cash flow sensitivity remains positive and significant advocating for the perceived effect of liquidity constraints on firm growth.

All the above findings are in line with those obtained by Carpenter and Petersen (2002), Audretsch and Elston (2006), Oliveira and Fortunato (2006) or

Fagiolo and Luzzi (2006), which show that smaller and younger firms experience higher growth rates, but their growth are hampered by liquidity constraints. The non-monotonic firm growth relationships with size and age are also prominent in studies which prefer to test such non-linearity.

4.6.3 Differential effects of internal finance on firm growth

The main proposition to be tested in this chapter is that the stronger the financial constraints, the larger the value of the observed growth-cash flow sensitivity. The same rational is applied here as in the empirical investment models that liquidity problems are exacerbated in the presence of capital market imperfections. As already discussed in chapter three, asymmetric information between borrowers and lenders of funds raises the cost of external finance and creates credit rationing and constrained access to credit. This influences real firm decisions such as investment in capital and as a consequence, firm growth as well. Firms with limited access to external capital markets will be highly reliant on the internal funds to finance their growth and their growth is thus likely to be severely affected by liquidity constraint problems. These firms can overcome such constraints by developing their credit status and with an increase in the firm's access to external financing, the effect of internal financing on firm growth should decrease.

In light of the Carpenter and Petersen (2002) model and the leverage effect, the range of values that the growth-cashflow sensitivity can exhibit from equation 4.6 can be explained by

$$0 < \frac{dGrowth}{dCash\ flow} \leq 1 + \lambda \tag{4.9}$$

where, λ is the raised collateral value of the firm by each additional unit of internally financed investment enabling constrained firms to take on more debt to finance growth and results in a more than one-to-one growth cash flow relationship. The value of λ or the magnified effect will be highest for firms facing the most binding financial constraints. On the other end, there are firms with most easy access to external finance. Even though such firms can in principle finance new investment projects or new assets completely by issuing new debt or equity, they still favor utilizing retained earnings over external funding for doing so. Therefore, their growth-cashflow sensitivity is expected to be small, but still greater than zero.

Table 4.6 shows the results of equation 4.6, where the predicted likelihood of facing unconstrained status is used to separate firm year observations into different categories and 4.6.a gives results of the corresponding diagnostics and other hypothesis tests. The estimates include only restricted lag levels and lag differences of size, age, cash flow interaction with different dummies and Tobin's Q as instruments for the difference and level equations respectively which are found to be jointly valid. In model 1, 2 and 3 cash flow is interacted with two category, three category and five category dummies respectively and in all the models, financial constraints are likely to be most binding for firm year observations in the lowest category according to the construction of the dummy categories variables. The general results of the baseline equation 4.5 are found to be effectual in all the three models in table 4.6, i.e, the non-monotonic U shaped relationship of firm growth with both firm size and age along with the negative impact of liquidity constraint on growth. Moreover, these three models bring out the heterogeneous responses of growth to cash flow among firm year observations in different parts of the predicted likelihood of facing unconstrained financial status distribution.

In Model 1, the estimated coefficient of cash flow for the most constrained group of firm year observations (those falling below the 50th percentile of the distribution of the predicted likelihood of facing unconstrained financial status) is positive and significant. The estimated growth-cashflow sensitivity implies that one unit increase of cash flow generates 1.53 unit growth in total assets. Therefore, according to equation 4.9, $\lambda = 0.53$, which is the raised collateral value for firm year observations in this group enabling them to get more leverage and have a multiplier effect on their growth by each additional unit cash flow (Carpenter and Petersen, 2002). The multiplier effect is more than 150% of the additional

Table 4.6: Differential effects using likelihood of facing financially unconstrained status

This table shows the differential effect of cash flow on growth across financially constrained and unconstrained firm years (separated with likelihood of facing financially unconstrained status with the lowest category as likely to be most financially constrained). Model 1 is estimated with two category dummies (50-50), Model 2 is estimated with three category dummies (0-25, 25-75, 75-100), Model 3 is estimated with five category dummies (0-20, 20-40, 40-60, 60-80, 80-100). Here, Cd stands for the dummies created by likelihood of facing unconstrained status. In addition to the full set of year dummies both as regressors and standard instruments, the estimates include lagged levels and lagged first differences of size, age, cash flow interaction with different dummies and Tobin's Q as instruments for the difference and level equations respectively. Standard errors in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	M1	M2	M3
L.size	-0.323***	-0.304**	-0.321**
	(0.112)	(0.127)	(0.127)
L.size^2	0.013***	0.012**	0.013**
	(0.005)	(0.005)	(0.005)
Age	-0.296***	-0.220***	-0.279***
	(0.061)	(0.058)	(0.061)
Age^2	0.054***	0.043***	0.051***
	(0.011)	(0.010)	(0.011)
Chf*Cd21 ($< 50^{th}p$)	1.530***		
	(0.135)		
Chf*Cd22 ($> 50^{th}p$)	0.525***		
	(0.158)		
Chf*Cd31 ($< 25^{th}p$)		1.764***	
		(0.180)	
Chf*Cd32 ($25^{th}p - 75^{th}p$)		0.810***	
		(0.152)	
Chf*Cd33 ($> 75^{th}p$)		0.442**	
		(0.209)	
Chf*Cd51 ($< 20^{th}p$)			1.810***
			(0.202)
Chf*Cd52 ($20^{th}p - 40^{th}p$)			1.334***
			(0.165)
Chf*Cd53 ($40^{th}p - 60^{th}p$)			0.879***
			(0.311)
Chf*Cd54 ($60^{th}p - 80^{th}p$)			0.408*
			(0.230)
Chf*Cd55 ($> 80^{th}p$)			0.256
			(0.395)
Tobin Q	0.105***	0.117***	0.107***
	(0.023)	(0.023)	(0.024)
Constant	2.142***	1.955***	2.127***
	(0.668)	(0.744)	(0.755)

Table 4.6.a: Diagnostics

The figures reported for the AR(2) and Hansen J tests are the p-values for their respective null hypotheses. AR(2) accepts the null hypothesis of no second-order serial correlation in the differenced residuals and Hansen J test accepts the null hypothesis that all instruments are jointly valid which implies that the instruments satisfy the required orthogonality conditions, i.e., their moments with the error term are zero.

	M1	M2	M3
AR(2) p-value	0.811	0.969	0.970
Hansen p-value	0.366	0.410	0.685
No of instruments	86	89	95
No of firms	1122	1122	1122
No of observations	11995	11995	11995

Wald tests to check hypotheses that the impact of cash flow on firm growth is same across firm years with two different financial constraint statuses.

	M1	M2	M3
Hypothesis	p-value	p-value	p-value
Chf*Cd21=Chf*Cd22	0.0000		
Chf*Cd31=Chf*Cd32		0.0000	
Chf*Cd32=Chf*Cd33		0.0427	
Chf*Cd51=Chf*Cd52			0.0500
Chf*Cd52=Chf*Cd53			0.0741
Chf*Cd53=Chf*Cd54			0.0668
Chf*Cd54=Chf*Cd55			0.6049

Calculation of the effect of one standard deviation change in cash flow on firm growth under different financial constraint status.

	M1	M2	M3
Cd21	0.385		
Cd22	0.051		
Cd31		0.520	
Cd32		0.113	
Cd33		0.039	
Cd51			0.549
Cd52			0.264
Cd53			0.102
Cd54			0.041
Cd55			0.022

unit of cash flow generated for this group. In a different note, this estimate means that an increase in cash flow by one standard deviation from the group mean raises the growth rate by 0.385 for this group (table 4.6.a). As expected, the second group in model 1 shows lower than one but positive (0.525) growth cash flow sensitivity and one standard deviation increase in cash flow for this category have a much lower impact (0.051) on growth rate. This lower cash flow effect is consistent with the fact that the firm year observations in this group have easy access to external financing which is reducing their dependence on cash flow for financing their growth. The p-value of the Wald test also reported in table 4.6.a rejects the null hypothesis that the impact of cash flow on firm growth is same across firm years between these two different financial constraint statuses as the estimated coefficients 1.530 and 0.525 are found statistically different.

In model 2, the estimated growth cash flow sensitivity of firm year observations under the 25th percentile of the distribution of the predicted index is 1.764 and gradually decreasing thereafter to 0.810 and 0.442 for firm year observations in the middle 50 percent and above the 75th percentile respectively. The effect of one standard deviation increase in cash flow on growth rate also monotonically decreases and the null hypotheses of equivalent cash flow affect on growth between any of the two categories are rejected.

In the most disaggregated model 3 where firm year observations are divided into five financial constraint categories, more heterogeneity in the growth cash flow sensitivity is revealed. However, the resulting pattern of the relationship are consistent with the first two models. As firm year observations moving from most to least financially constrained categories, the effect of internal financing on firm growth decreases monotonically with the estimated cash flow coefficient ranging from highest 1.810 to the lowest 0.256.

In all these models, the results consistently indicate a substantially greater sensitivity of growth to cash flow for firm years belonging to the most constrained categories which are most likely to face severe asymmetric information related problems leading to binding financial constraints on their growth. Furthermore, these firms can actually expand their size more than the extent of increase in cash flow they may have supporting the leverage effect hypothesis. The estimated impact decreases monotonically thereafter as their financial constraints become less binding. The estimated differentials between different classes are mostly statistically significant. These results are consistent with the cost differential between internal and external finance described earlier.

Table 4.7 represents the estimated results of equation 4.6, where the only difference is the index used to separate firm year observations into different financial constraint categories. Instead of the likelihood of facing unconstrained financial status, the predicted corporate efficiency index from chapter two is used here to construct the dummy category variables, but in similar fashion. That means firm year observations in the lowest category have least corporate efficiency and hence, are likely to face most binding financing constraints. As it has been found in chapter three that corporate efficiency positively affects a firm's probability of facing unconstrained financial status, classification using this index can also successfully expose the heterogeneous impact of liquidity constraints on firm growth. Similarity between the three model specifications in table 4.7 with the corresponding ones in table 4.6 are strictly maintained in all other aspects including the sets of instruments and their lag structure.

The estimated growth cash flow sensitivity of the most financially constrained group of firm year observations in model 1, 2 and 3 are all greater than one which demonstrates the leverage effect, i.e, each additional unit of internally generated funds enable firms to achieve a magnified effect on their growth. And within each of these models, the estimated coefficients monotonically decrease with firm year observations moving from left to right of the distribution of the corporate efficiency index. This is consistent not only within each model, but also across the three models. Growth of firm year observations on top 20% of the distribution in model 3 are less sensitive to cash flow in comparison with those on top 25% in model 2 or top 50% in model 1. The same is true at the other ends of the

Table 4.7: Differential effects using corporate efficiency index

This table shows the differential effect of cash flow on growth across financially constraint and unconstrained firm years (separated with corporate efficiency index with the lowest category as likely to be most financially constrained). Model 1 is estimated with two category dummies (50-50), Model 2 is estimated with three category dummies (0-25, 25-75, 75-100), Model 3 is estimated with five category dummies (0-20, 20-40, 40-60, 60-80, 80-100). Here, Ed stands for the dummies created by corporate efficiency index. In addition to the full set of year dummies both as regressors and standard instruments, the estimates include lagged levels and lagged first differences of size, age, cash flow interaction with different dummies and Tobin's Q as instruments for the difference and level equations respectively. Standard errors in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	M1	M2	M3
L.size	-0.378***	-0.394***	-0.397***
	(0.122)	(0.125)	(0.096)
L.size^2	0.015***	0.016***	0.016***
	(0.005)	(0.005)	(0.004)
Age	-0.235***	-0.224***	-0.277***
	(0.063)	(0.056)	(0.064)
Age^2	0.041***	0.039***	0.045***
	(0.011)	(0.010)	(0.012)
Chf*Ed21 ($< 50^{th}p$)	1.348***		
	(0.130)		
Chf*Ed22 ($> 50^{th}p$)	0.880***		
	(0.168)		
Chf*Ed31 ($< 25^{th}p$)		1.485***	
		(0.177)	
Chf*Ed32 ($25^{th}p - 75^{th}p$)		1.100***	
		(0.118)	
Chf*Ed33 ($> 75^{th}p$)		0.589**	
		(0.242)	
Chf*Ed51 ($< 20^{th}p$)			1.670***
			(0.193)
Chf*Ed52 ($20^{th}p - 40^{th}p$)			1.363***
			(0.142)
Chf*Ed53 ($40^{th}p - 60^{th}p$)			1.056***
			(0.131)
Chf*Ed54 ($60^{th}p - 80^{th}p$)			0.885***
			(0.154)
Chf*Ed55 ($> 80^{th}p$)			0.373
			(0.242)
Tobin Q	0.102***	0.099***	0.083***
	(0.025)	(0.025)	(0.021)
Constant	2.401***	2.497***	2.605***
	(0.721)	(0.739)	(0.550)

Table 4.7.a: Diagnostics

The figures reported for the AR(2) and Hansen J tests are the p-values for their respective null hypotheses. AR(2) accepts the null hypothesis of no second-order serial correlation in the differenced residuals and Hansen J test accepts the null hypothesis that all instruments are jointly valid which implies that the instruments satisfy the required orthogonality conditions, i.e., their moments with the error term are zero.

	M1	M2	M3
AR(2) p-value	0.761	0.755	0.735
Hansen p-value	0.444	0.334	0.323
No of instruments	86	89	95
No of firms	1122	1122	1122
No of observations	11995	11995	11995

Wald tests to check hypotheses that the impact of cash flow on firm growth is same across firm years with two different financial constraint statuses.

	M1	M2	M3
Hypothesis	p-value	p-value	p-value
Chf*Ed21=Chf*Ed22	0.009		
Chf*Ed31=Chf*Ed32		0.021	
Chf*Ed32=Chf*Ed33		0.021	
Chf*Ed51=Chf*Ed52			0.097
Chf*Ed52=Chf*Ed53			0.030
Chf*Ed53=Chf*Ed54			0.226
Chf*Ed54=Chf*Ed55			0.010

Calculation of the effect of one standard deviation change in cash flow on firm growth under different financial constraint status.

	M1	M2	M3
Ed21	0.318		
Ed22	0.112		
Ed31		0.392	
Ed32		0.180	
Ed33		0.069	
Ed51			0.452
Ed52			0.275
Ed53			0.164
Ed54			0.106
Ed55			0.046

distribution. Therefore, in line with the findings in chapter three, these results indicate that firms can recover from their credit constraints through the improvement of corporate efficiency. They can finance successively bigger portion of their growth through external financing source without being severely constrained by internally generated funds which is making their growth successively less sensitive to cash flow. Results of AR(2) and Hansen test in 4.7.a suffices the validity of the estimates. Wald test results also support the differential effect of liquidity constraints on growth rate between any of the two different categories with only one exception in model 3.

4.6.4 Robustness check

In place of the two novel proxies used to classify firm years into different financial constraint status, we use other traditional measures to construct the financial constraint dummy variables in similar ways to categorize firm year observations into financially constrained or unconstrained status.

The propositions and the results obtained so far in this chapter are all based on the fact that the cashflow sensitivity is a practicable mode of detecting the relative importance of financing problems across firms of different credit status following Fazzari et al. (1988). They classify low dividend paying firms as financially constrained as such firms prefer to retain all of their low-cost internal funds they can generate before going to high cost external funds to finance their investment and we use the same classification criteria as the first robustness check of our results.

Sufi (2009) and Rahman (2011) use line of credit as the classification criteria arguing that the degree of access to a bank credit facility is a good measure of a firm's external financing constraints. According to the theoretical literature, lines of credit are committed liquidity insurance that ensures availability of funds for valuable projects and thus protects firms against future capital market frictions. However, lines of credit can only provide sufficient liquidity insurance to those firms in the economy which find it convenient to obtain and maintain. These firms can be labeled as financially unconstrained. Therefore, with greater access to a bank credit facility, the firms will become more financially unconstrained and the effect of internal financing on firm growth should decrease. We calculate line of credit as the ratio of short term debt to total liability following Rahman (2011).

Firm size and age are two of the most widely used classification criteria in the investment and financial constraint literature and have been used by Wagenvoort (2003) and Oliveira and Fortunato (2006) in their examination of differential effect of liquidity constraints on growth. They expect that the liquidity problems to be particularly severe for smaller and younger firms who have limited access to capital both in terms of availability and accessibility because such firms are characterized by idiosyncratic risk, may not have sufficient industry experience to be distinguished as credit worthy by outside investors and may not have enough collateral and all these make them face costly and limited access to external credits.

Table 4.8 shows the estimated results where firm year observations are separated with dividend in model 1, line of credit in model 2, firm size in model 3 and firm age in model 4. All models here are estimated with two category dummies with firm year observations lying below the 50th percentile of the respective distributions as financially constrained and unconstrained otherwise. In all these models, the previously obtained results are found robust. The estimated investment cash flow sensitivity for all different financial constraint classes remain positive and significant with the estimated coefficient always greater than one for the most financially constrained firm year observations supporting the leverage effect hypothesis. The estimated cash flow coefficient for the unconstrained classes are significantly lower and the difference in cash flow effects among the two classes are always statistically significant (4.8.a).

Finally, as sales is used as a proxy for firm size in the first two chapters, natural logarithm of sales is used to capture firm size and growth in sales is used to

Table 4.8: Robustness checks using other traditional measures of financial constraints

This table shows the differential effect of cash flow on growth across financially constrained and unconstrained firm years (separated with dividend in model 1, line of credit in model 2, firm size in model 3 and firm age in model 4 with the lowest category as likely to be most financially constrained). All models here are estimated with two category dummies. Here, Dd, Ld, Sd and Ad stands for the dummies created by dividend, line of credit, size and age respectively. In addition to the full set of year dummies both as regressors and standard instruments, the estimates include lagged levels and lagged first differences of size, age, cash flow interaction with different dummies and Tobin's Q as instruments for the difference and level equations respectively. Standard errors in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	M1	M2	M3	M4
L.size	-0.358***	-0.352***	-0.309***	-0.339***
	(0.101)	(0.105)	(0.114)	(0.096)
L.size^2	0.014***	0.014***	0.012***	0.013***
	(0.004)	(0.004)	(0.004)	(0.004)
Age	-0.229***	-0.225***	-0.285***	-0.279***
	(0.062)	(0.064)	(0.066)	(0.065)
Age^2	0.038***	0.040***	0.048***	0.057***
	(0.012)	(0.012)	(0.012)	(0.012)
Chf*Dd21 ($< 50^{th}p$)	1.747***			
	(0.139)			
Chf*Dd22 ($> 50^{th}p$)	0.541*			
	(0.302)			
Chf*Ld21 ($< 50^{th}p$)		1.234***		
		(0.162)		
Chf*Ld22 ($> 50^{th}p$)		0.897***		
		(0.227)		
Chf*Sd21 ($< 50^{th}p$)			1.561***	
			(0.144)	
Chf*Sd22 ($> 50^{th}p$)			0.726**	
			(0.323)	
Chf*Ad21 ($< 50^{th}p$)				1.397***
				(0.141)
Chf*Ad22 ($> 50^{th}p$)				0.516***
				(0.198)
Tobin Q	0.115***	0.083***	0.103***	0.103***
	(0.025)	(0.021)	(0.027)	(0.025)
Constant	2.322***	2.262***	2.057***	2.191***
	(0.592)	(0.630)	(0.691)	(0.572)

Table 4.8.a: Diagnostics

The figures reported for the AR(2) and Hansen J tests are the p-values for their respective null hypotheses. AR(2) accepts the null hypothesis of no second-order serial correlation in the differenced residuals and Hansen J test accepts the null hypothesis that all instruments are jointly valid which implies that the instruments satisfy the required orthogonality conditions, i.e., their moments with the error term are zero.

	M1	M2	M3	M4
AR(2) p-value	0.661	0.592	0.644	0.852
Hansen p-value	0.514	0.583	0.341	0.308
No of instruments	86	86	86	86
No of firms	1122	1122	1122	1122
No of observations	11995	11995	11995	11995

Wald tests to check hypotheses that the impact of cash flow on firm growth is same across firm years with two different financial constraint statuses.

	M1	M2	M3	M4
Hypothesis	p-value	p-value	p-value	p-value
Chf*Dd21=Chf*Dd22	0.001			
Chf*Ld21=Chf*Ld22		0.032		
Chf*Sd21=Chf*Sd22			0.023	
Chf*Ad21=Chf*Ad22				0.000

Calculation of the effect of one standard deviation change in cash flow on firm growth under different financial constraint status.

	M1	M2	M3	M4
Dd21	0.427			
Dd22	0.042			
Ld21		0.268		
Ld22		0.162		
Sd21			0.398	
Sd22			0.053	
Ad21				0.349
Ad22				0.058

measure firm growth to carry on the final robustness check of our results. However, this output based measure of growth may not necessarily allow to make the quantitative prediction about the growth-cash flow relationship as all potential usage of internal funds may not be properly reflected by growth in sales and thus may not be suitable for capturing the real effects of financial constraints on firm growth. The results using this alternative measure of firm size and growth are presented in appendix C. The re-specified baseline equation 4.5 is estimated again using OLS, FE, difference and system-GMM to check for the presence of finite sample biases and table C.2 (pp. 169) reiterate the similar conclusion came out earlier that the system-GMM produces better results in estimating such dynamic equations. Growth rate in sales is also found to have the U shaped relationship with size and age and liquidity constraints similarly generate a negative impact on sales growth. Table C.3 (p. 170) shows the estimated results of the extended models where the two novel proxies (likelihood of facing financially unconstrained status in model 1 and corporate efficiency index in model 2) along with two traditional ones (dividend in model 3 and line of credit in model 4) are used to bring out differential effects of internal finance on firm growth and here as well, all models are estimated with two category dummies only. The results are robust in the sense that the estimated coefficients of cash flow for the unconstrained firm year observations fall significantly short of those for the constrained ones in any of these models. The estimations pass the usual diagnostics tests as shown in C.3.a. However, the constrained firm years are now showing less than a one to one relationship between cashflow and growth of their sales which is a contradiction with the leverage effect hypothesis tested earlier.

4.7 Conclusion

Combining two aspects of economic literature, this chapter attempts to relate financial constraints to the dynamics of firm size and growth to explain whether the heterogeneity in firms' growth can be explained by the degree of financial constraint status they face by developing the Carpenter and Petersen (2002) model. On the way to do that, our empirical strategy strives to tackle the common problems in estimating dynamic growth equation and makes quantitative predictions about the relationship between growth and internal finance across firm years in different credit status using our two novel proxies for financial constraints. The results in general reject Gibrat's law of proportionate effect and we find that smaller and younger firms grow faster. Overall, the relationship of firm size and age with growth is found non-monotonic U-shaped which is consistent with previous literatures. The availability of internal funds is also found to be important for overall firm growth. Not only that, the estimated results from all our model specifications consistently indicate a substantially greater sensitivity of growth to cash flow for firm years belonging to the most financially constrained categories which are most likely to face more severe asymmetric information related problems leading to binding financial constraints on their growth. Furthermore, these firms can actually expand their size more than the extent of positive income shock they may face supporting the leverage effect hypothesis. The estimated impact decreases monotonically thereafter as their financial constraints become less binding which allow them to finance successively bigger portion of their growth through external financing source without being severely constrained by internally generated funds. These empirically important differences across firm years are consistent with financial constraints arising from capital market imperfections.

Chapter 5

Conclusion

The primary aim of this thesis is to study the impact of financial market frictions on firm performance employing different empirical strategies and econometric techniques. However, all our empirical investigations are carried out using one single dataset covering the same unbalanced panel of 1122 UK firms listed on the London Stock Exchange over the period 1981 to 2009. This final chapter summarizes the major findings from the three empirical chapters of the thesis and acknowledges their possible limitations. It also portrays the implications for policy pertaining to real and financial activities of the firms and suggests potential extensions that can be conducted in the future.

5.1 Summary and implications of the findings

In the first empirical chapter, we have predicted long run corporate efficiency focusing on value maximization and short run corporate efficiency focusing on profit maximization approach. Our predictions indicate that an average firm in the UK suffers from performance shortfall due to inefficiency or agency conflicts, no matter which approach is adopted. However, these two different perspectives have important bearing on how the predicted efficiencies evolve. The short run efficiency supports the agency cost of outside debt and the long run efficiency supports the agency cost of outside equity hypothesis. Also, the long run efficiency is found to be consistently lower than the short run efficiency which may be considered as the cost of focusing on an array of objectives rather than on maximizing profit only. Contrary to such costs, these longer term broader objectives can potentially ensure a healthy and sustainable firm performance. This is why managers of modern corporations are expected to follow this modern value maximization approach of financial management, which can lead to better and more accurate evaluation of business.

Inspired by the findings of chapter two, we have taken up the proposition that corporate efficiency can simultaneously affect a firm's financial constraint status and investment responsiveness to internal financing. Our endogenous and interchangeable firm classification results reveal that financially constrained firms are more likely to be smaller, younger, deficient in capturing better investment opportunity, reserve higher safety stock, pay low dividends, have less collaterizable assets, less external debt and most importantly, are inferior in terms of corporate efficiency. Turning to their investment behavior, they are comparatively more sensitive to the availability of both the stock and flow measure of internal liquidity pertaining to the idea of imperfect substitutability between internal and external financing source under market imperfections. The much controversial role of cash flow in detecting such imperfections is also given a critical resolution by the decreasing investment cash flow sensitivity with corporate efficiency for these firms. If the mismeasured investment opportunity solely drives the high investment cash flow sensitivity, then it shouldn't be decreasing with improvement of efficiency. Our direct measure of corporate efficiency as an inverse proxy of the extent of asymmetric information and agency conflict problems, thus plays a convincing role here. Our results also support the credit multiplier theory according to which the investment cash flow sensitivity increases with tangibility for both the constrained and unconstrained firms. The important implications of our findings to managers and financiers is that, by improving corporate efficiency or in other words, by mitigating agency conflict, taking optimal operating, financing and investment decisions, borrowers can render signals to the outside investors about the actual status of the firm which will then determine the availability and accessibility of external finance for them. An implication of our findings for researchers is that, cross-sectional variation in the investment sensitivity to internal finance may still be interpreted as a consequence of capital market imperfections.

The final empirical chapter reaffirms the finding that a differential effect of internal finance arises due to capital market imperfections, but from a different conceptual and analytical perspective. In contrast to the qualitative predictions made in chapter three, here we have attempted to determine the extent of growth that can be generated by an additional unit of internal finance. Our results consistently reveal that the sensitivity of growth to cash flow for a firm is highest when the financial constraints is most binding for the firm. Moreover, due to a leverage effect, the firm can actually expand it's size more than the extent of change in cash flow. With the easing of financial constraints, a firm can increasingly finance it's growth by external sources and the incremental effect of internal finance on growth falls monotonically. The results suggest important policy implications for financially constrained firms which should be taken into consideration while formulating their real activities because growth is particularly restricted by the profit generating capacity of their existing production facilities. By improving this capacity, they can potentially enjoy an accelerated and magnified effect of a potential positive income shock on their growth.

5.2 Limitations

We are also aware of some possible limitations of the empirical results we have presented in this thesis. First of all, in the stochastic frontier model, relating the shortfall from the frontier to monitoring and incentive variables could explain the reasons for the failure to maximize value or profit. Even though, our explanatory variables for the inefficiency equation give reasonable explanations for the shortfall, a different set of variables like ownership and corporate governance structure could provide further insight about our measured corporate efficiency. We could not manage to collect any proxy for such variables for our sample firms from the chosen database.

Cash flow, financial slack and Tobin's Q in an investment equation can be endogenous and we have checked the robustness of our results by including these variables as one period lagged form. Even though our results suggest that the sensitivity of investment to the availability of internal funds is not solely driven by measurement error in investment opportunity, we are not claiming that Tobin's Q, as our proxy for such is free from measurement error. Usually, an instrumental variable technique or error correction models are suggested for tackling these problems, but none of those could be incorporated within the switching regression framework. For the same reason, we have not estimated our investment equation in a dynamic form. However, we believe that the advantages of the switching regression model outweigh these disadvantages.

5.3 Implications for future research

Our sample consists of only the quoted firms in the UK, on which all our empirical results are obtained. It will be an worthy venture to conduct similar investigations after including the unquoted firms in our sample as well because the unquoted firms are prone to a comparatively wider range of adverse financial attributes and thus may face more restricted access to external finance than the quoted ones. This will not only benefit us from having wider range of variation across observations in the sample, but also allow us to deal with more extensive research questions. However, this may require us to change the methodology we have followed in this thesis and also the interpretations we have made. Inclusion of unquoted firms will restrict us from estimating market value efficiency or using Q theory of investment in our switching regression model as Tobin's Q cannot be calculated for unquoted firms. However, we can still measure the short run efficiency using the profit frontier. For estimating the investment equations in the switching regression model, we can use the accelerator model of investment following Hobdari et al. (2009) which will similarly allow us to capture the differential effects of cash flow on investment.

In this thesis we have focused on investment cash flow sensitivity and growth cash flow sensitivity to determine the impact of financial constraints arising from capital market imperfections. Almeida et al. (2004) suggest a third approach named as cash flow sensitivity of cash, which relies on the fact that financial constraints should be related to a firm's propensity to save cash out of cash inflows as well. According to their proposition, financially unconstrained firms should not display a systematic propensity to save cash, while firms that are constrained should have a positive cash flow sensitivity of cash. They estimate this sensitivity for a priori classified unconstrained and constrained subsamples using payout policy, asset size, bond ratings, commercial paper ratings, and the "KZ" index derived from the results in Kaplan and Zingales (1997). Therefore, similar static and dynamic misclassification problems may affect their results. We can attempt to predict the differential cash flow sensitivity of cash by using the switching regression framework. Tobin's Q as proxy for investment opportunity is included by Almeida et al. (2004) in their model specification, however excluded by D'Espallier et al. (2008) in making similar predictions. Therefore, we can follow any of these in specifying our equations based on our sample.

Any three of these sensitivities to measure the effect of financial constraints on constrained and unconstrained firms' financial policies can be altered to capture the similar impact on that of quoted and unquoted firms. Guariglia (2008) investigates the investment cash flow sensitivity for the unquoted firms and Rahman (2011) compares the growth cash flow sensitivity between quoted and unquoted firms. A stark difference with the unobserved constrained and unconstrained status is that a firm's private and public status is readily observable. Further, taking into consideration that firms can switch between these two status, we can use the endogenous switching regression model with one regime observed following Lokshin and Sajaia (2004) or a dummy variable interaction technique.

These plausibly can give us an indication about the wideness of the domain of our selected research area. Despite having some limitations, the research questions taken up for this thesis, the methodologies used to find out their answers and finally the results and implications that come forth can possibly fill up some gaps in the existing literature and help us to better understand the channels through which market imperfections led financial constraint problems may affect firm performance.

Appendix A:

Figure A.1: Market imperfections and investment cash flow sensitivity

This figure taken from Hubbard (1998) shows the links among net worth, the cost of external financing, and investment. Holding information costs constant, when net worth increases from W_0 to W_1, the supply-of-funds curve shifts right. For firms facing high information costs, this increase in net worth, holding both information costs and investment opportunities constant, increases the capital stock from K_0 to K_1. But, for a firm facing no information costs or with sufficient net worth (or internal funds) to finance it's desired capital stock, an increase in net worth independent of changes in investment opportunities has no effect on investment and equilibrium capital stock remains at K^*.

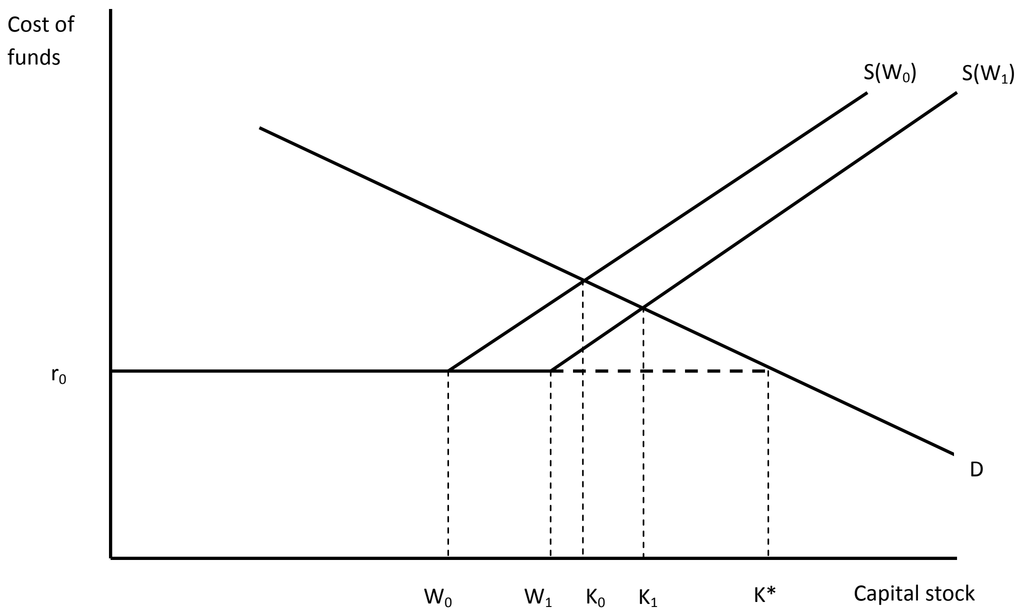


Table A.1: FTSE/Dow Jones Industrial Classification Benchmark (ICB) codes

The FTSE/Dow Jones Industrial Classification Benchmark (ICB) is adopted by Thomson Financial as it's standard classification tool across a number of it's global databases and these ICB codes are available within Worldscope. Financial industry (8000) along with it's supersectors and sectors has been dropped from this table.

Industry	Supersector	Sector
0001 Oil & Gas	0500 Oil & Gas	0530 Oil & Gas Producers
		0570 Oil Equipment, Services & Distribution
		0580 Alternative Energy
1000 Basic Materials	1300 Chemicals	1350 Chemicals
	1700 Basic Resources	1730 Forestry & Paper
		1750 Industrial Metals & Mining
		1770 Mining
2000 Industrials	2300 Construction & Materials	2350 Construction & Materials
	2700 Industrial Goods & Services	2710 Aerospace & Defense
		2720 General Industrials
		2730 Electronic & Electrical Equipment
		2750 Industrial Engineering
		2770 Industrial Transportation
		2790 Support Services

3000 Consumer Goods	3300 Automobiles & Parts	3350 Automobiles & Parts
	3500 Food & Beverage	3530 Beverages 3570 Food Producers
	3700 Personal & Household Goods	3720 Household Goods & Home Construction 3740 Leisure Goods 3760 Personal Goods 3780 Tobacco
4000 Health Care	4500 Health Care	4530 Health Care Equipment & Services 4570 Pharmaceuticals & Biotechnology
5000 Consumer Services	5300 Retail	5330 Food & Drug Retailers 5370 General Retailers
	5500 Media	5550 Media
	5700 Travel & Leisure	5750 Travel & Leisure
6000 Telecom	6500 Telecom	6530 Fixed Line Telecom 6570 Mobile Telecom
7000 Utilities	7500 Utilities	7530 Electricity 7570 Gas, Water & Multi-utilities
9000 Technology	9500 Technology	9530 Software & Computer Services 9570 Technology Hardware & Equipment

A.2 Worldscope data definition along with their field number/ identifier

Total assets (02999): Total asset represent the sum of total current assets, long term receivables, investment in unconsolidated subsidiaries, other investments, net property plant and equipment and other assets.

Common equity (03501): Common equity represents common shareholders' investment in a company. It includes but is not restricted to: common stock value, retained earnings, capital surplus, capital stock premium etc.

Market capitalization (08001): Market Price-Year End * Common Shares Outstanding. Common shares outstanding represent the number of shares outstanding at the company's year end. It is the difference between issued shares and treasury shares.

Net sales or revenue (01001): Net sales or revenues represent gross sales and other operating revenue less discounts, returns and allowances.

Long term debt (03251): Long term debt represents all interest bearing financial obligations, excluding amounts due within one year. It is shown net of premium or discount.

Short term debt and current portion of long term debt (03051): Short term debt and current portion of long term debt represents that portion of debt payable within one year including current portion of long term debt and sinking fund requirements of preferred stock or debentures. It includes but is not restricted to: current portion of long-term debt (the amount of long term debt due within the next twelve months), notes payable arising from short-term borrowings, current portion of advances and production payments, bank overdrafts, advances from subsidiaries/associated companies, current portion of preferred stock of a subsidiary etc.

Capital expenditures (04601): Capital expenditures represents the funds used to acquire fixed assets other than those associated with acquisition. It includes but is not restricted to: additions to property, plant and equipment, investments in machinery and equipment.

Total intangible other assets-net (02649): Total intangible other assets (net) represent other assets not having a physical existence. The value of these assets lies in their expected future return.

Property, plant and equipment-net (02501): Property, plant and equipment (net) represents gross property, plant and equipment less accumulated reserves for depreciation, depletion and amortization.

Cash dividend paid-total (04551): Total cash dividends paid represent the total common and preferred dividends paid to shareholders of the company. It excludes dividends paid to minority shareholders.

Earnings before interest, taxes and depreciation (18198): Earnings before interest, taxes and depreciation represent the earnings of a company before interest expense, income taxes and depreciation. It is calculated by taking the pre-tax income and adding back interest expense on debt and depreciation, depletion and amortization and subtracting interest capitalized.

Funds from operation (04201): Funds from operations represents the sum of net income and all non-cash charges or credits. It is the cash flow of the company. If a statement of changes in financial position has not been provided, but the company discloses an aggregate cash flow, this amount has been used. Where cash flow has not been disclosed in any manner, it is estimated based on net profit before preferred dividends plus depreciation, reserves charges, provision for loan losses for banks, and provision for future benefits for insurance companies.

Cash and short term investment (02001): Cash and short term investment represents the sum of cash and short term investments. It includes but is not restricted to: cash on hand, undeposited checks, cash in banks, checks in transit, credit card sales, drafts, money orders, letters of credit, demand deposits (non-interest bearing), stocks, bonds, or other marketable securities listed as short-term investments, time deposits, corporate securities - stocks, bonds, commercial paper, money market mutual fund shares, central bank deposits, temporary investments etc.

Interest expense on debt (01251): Interest expense on debt represents the service charge for the use of capital before the reduction for interest capitalized. If interest expense is reported net of interest income, and interest income cannot be found the net figure is shown.

Appendix B:

Table B.1: Correlation of the probability of facing unconstrained financial status with the selection variables

This table gives the correlation coefficients along with the significance level (5%) of the predicted likelihood of facing unconstrained financial statuses from the two models in table 3.2 with the selection variables in equation 3.10.

	PFU_{Model1}	PFU_{Model2}
Size	0.711*	0.779*
	0.000	0.000
Age	0.725*	0.737*
	0.000	0.000
Dividend	0.362*	0.373*
	0.000	0.000
St.leverage	0.170*	0.158*
	0.006	0.006
Lt.leverage	0.284*	0.274*
	0.000	0.000
Tobin's Q	-0.342*	-0.396*
	0.000	0.000
Int.cov.ratio	0.197*	0.203*
	0.000	0.000
Fin.slack	-0.532*	-0.584*
	0.000	0.000
Mv.efficiency	0.650*	0.710*
	0.004	0.004
Tangibility	0.613*	0.517*
	0.000	0.000

Appendix C:

Figure C.1: Growth cash flow sensitivity and "leverage" effect

This figure taken from Carpenter and Petersen (2002) shows the leverage effect which occurs when firms' access to debt depends on collateral. Due to increase in cash flow, the external finance curve (S) shifts rightward to (S''). This allows a change in internal finance ($CF' - CF$) to have a multiplier effect on asset growth ($\triangle A'' - \triangle A$) through leverage.

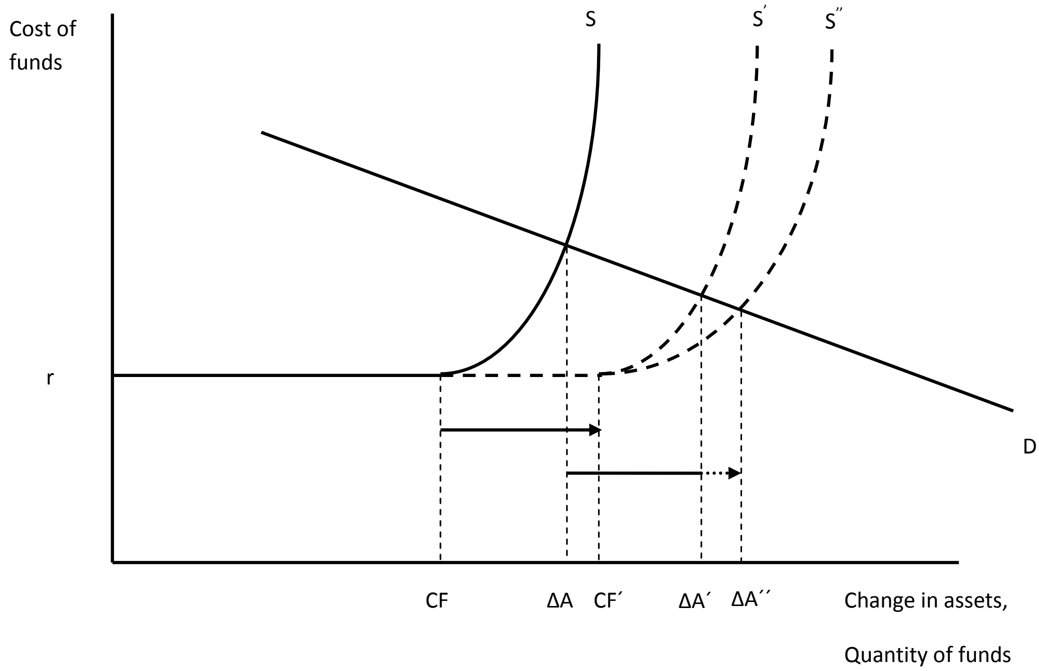


Table C.1: AR(1) specification with size as dependent variable

This table shows the estimated results of equation 4.1 using OLS, FE, Difference and System GMM. OLS estimates include a full set of sector and year dummies as regressors, FE estimates include a full set of year dummies as regressors, GMM estimates include a full set of year dummies both as regressors and instruments. In addition to these, difference GMM estimates include L(2/4). size collapsed and system GMM estimates include L(2/4). size collapsed and DL(1/1). size collapsed as instruments for the difference and level equations respectively. Standard errors in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	OLS	FE	Diff-GMM	Sys-GMM
L.size	0.981***	0.805***	0.632***	0.966***
	(0.002)	(0.011)	(0.059)	(0.008)
Constant	0.393***	2.227***		0.337***
	(0.041)	(0.115)		(0.087)

Table C.1.a: Diagnostics

The figures reported for the AR(2) and Hansen J tests are the p-values for their respective null hypotheses. AR(2) accepts the null hypothesis of no second-order serial correlation in the differenced residuals and Hansen J test accepts the null hypothesis that all instruments are jointly valid which implies that the instruments satisfy the required orthogonality conditions, i.e., their moments with the error term are zero.

	OLS	FE	Diff-GMM	Sys-GMM
AR(2) p-value			0.185	0.102
Hansen p-value			0.209	0.294
No of instruments			31	32
No of firms		1122	1122	1122
No of observations	11995	11995	10807	11995

Table C.2: Robustness check using sales as proxy for firm size

This table shows the estimated results of equation 4.5 using sales as a proxy for firm size and growth in sales as a measure of firm growth instead and OLS, FE, Difference and System GMM results are presented in it's four columns. OLS estimates include a full set of sector and year dummies as regressors, FE estimates include a full set of year dummies as regressors, GMM estimates include a full set of year dummies both as regressors and instruments. In addition to these, difference GMM estimates include lagged levels of size, age, cash flow and Tobin's Q as instruments for the first differenced equation and system GMM estimates include the lagged levels and lagged first differences of size, age, cash flow and Tobin Q as instruments for the differenced and the level equations respectively. Standard errors in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	OLS	FE	Diff-GMM	Sys-GMM
L.size	-0.231***	-0.754***	-0.505**	-0.235***
	(0.026)	(0.070)	(0.211)	(0.057)
L.size^2	0.009***	0.024***	0.006	0.009***
	(0.001)	(0.003)	(0.014)	(0.002)
Age	-0.355***	-0.275*	-0.231	-0.178*
	(0.055)	(0.141)	(0.188)	(0.101)
Age^2	0.060***	0.110**	0.127*	0.042**
	(0.011)	(0.048)	(0.066)	(0.018)
Cash flow	0.708***	1.092***	0.887*	0.713***
	(0.072)	(0.115)	(0.455)	(0.206)
Tobin Q	-0.004	-0.028**	0.041	0.081**
	(0.006)	(0.013)	(0.039)	(0.033)
Constant	2.079***	5.490***		1.458***
	(0.163)	(0.354)		(0.295)

Table C.2.a: Diagnostics

The figures reported for the AR(2) and Hansen J tests are the p-values for their respective null hypotheses. AR(2) accepts the null hypothesis of no second-order serial correlation in the differenced residuals and Hansen J test accepts the null hypothesis that all instruments are jointly valid which implies that the instruments satisfy the required orthogonality conditions, i.e., their moments with the error term are zero.

	OLS	FE	Diff-GMM	Sys-GMM
AR(2) p-value			0.185	0.181
Hansen p-value			0.019	0.230
No of instruments			77	83
No of firms		1122	1122	1122
No of observations	11995	11995	10807	11995

Table C.3: Differential effects on sales growth using different proxies for financial constraints

This table shows the differential effect of cash flow on growth across financially constrained and unconstrained firm years (separated with likelihood of facing unconstrained financial status in model 1, predicted corporate efficiency in model 2, dividend payout in model 3 and line of credit in model 4 with the lowest category as likely to be most financially constrained). All models here are estimated with two category dummies. Here, Cd, Ed, Dd and Ld stands for the dummies created by constraint status, efficiency index, dividend and line of credit respectively. In addition to the full set of year dummies both as regressors and standard instruments, the estimates include lagged levels and lagged first differences of size, age, cash flow interaction with different dummies and Tobin's Q as instruments for the difference and level equations respectively. Standard errors in parentheses; ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively.

	M1	M2	M3	M4
L.size	-0.233***	-0.224***	-0.220***	-0.239***
	(0.056)	(0.056)	(0.055)	(0.054)
L.size^2	0.009***	0.009***	0.009***	0.009***
	(0.002)	(0.002)	(0.002)	(0.002)
Age	-0.185**	-0.185**	-0.191**	-0.173**
	(0.087)	(0.093)	(0.084)	(0.086)
Age^2	0.038**	0.039**	0.039**	0.035**
	(0.016)	(0.017)	(0.015)	(0.016)
Chf*Cd21 ($< 50^{th}p$)	0.837***			
	(0.276)			
Chf*Cd22 ($> 50^{th}p$)	0.450*			
	(0.249)			
Chf*Ed21 ($< 50^{th}p$)		0.751***		
		(0.291)		
Chf*Ed22 ($> 50^{th}p$)		0.501***		
		(0.183)		
Chf*Dd21 ($< 50^{th}p$)			0.860***	
			(0.274)	
Chf*Dd22 ($> 50^{th}p$)			0.367*	
			(0.190)	
Chf*Ld21 ($< 50^{th}p$)				0.924***
				(0.255)
Chf*Ld22 ($> 50^{th}p$)				0.540**
				(0.235)
Tobin Q	0.087***	0.087***	0.095***	0.085***
	(0.030)	(0.031)	(0.030)	(0.027)
Constant	1.428***	1.373***	1.369***	1.452***
	(0.316)	(0.326)	(0.319)	(0.301)

Table C.3.a: Diagnostics

The figures reported for the AR(2) and Hansen J tests are the p-values for their respective null hypotheses. AR(2) accepts the null hypothesis of no second-order serial correlation in the differenced residuals and Hansen J test accepts the null hypothesis that all instruments are jointly valid which implies that the instruments satisfy the required orthogonality conditions, i.e., their moments with the error term are zero.

	M1	M2	M3	M4
AR(2) p-value	0.181	0.186	0.179	0.177
Hansen p-value	0.415	0.366	0.342	0.400
No of instruments	86	86	86	86
No of firms	1122	1122	1122	1122
No of observations	11995	11995	11995	11995

Wald tests to check hypotheses that the impact of cash flow on firm growth is same across firm years with two different financial constraint statuses.

	M1	M2	M3	M4
Hypothesis	p-value	p-value	p-value	p-value
Chf*Cd21=Chf*Cd22	0.086			
Chf*Ed21=Chf*Ed22		0.124		
Chf*Dd21=Chf*Dd22			0.031	
Chf*Ld21=Chf*Ld22				0.087

Calculation of the effect of one standard deviation change in cash flow on firm growth under different financial constraint status.

	M1	M2	M3	M4
Cd21	0.182			
Cd22	0.081			
Ed21		0.191		
Ed22		0.037		
Dd21			0.215	
Dd22			0.041	
Ld21				0.231
Ld22				0.061

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