Article:

Quader, M. and Taylor, K.B. orcid.org/0000-0002-6525-0815 (2017) Corporate efficiency, credit status and investment. European Journal of Finance. ISSN 1351-847X

https://doi.org/10.1080/1351847X.2017.1312475

Corporate efficiency, credit status and investment

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Abstract

This paper considers the relationship between financial frictions and investment. In an effort to clarify the role of cash flow in examining the impact of capital-market imperfections, endogenous switching regression models (SRM) are estimated for a panel of 1122 UK firms listed on the London Stock Exchange over the period of 1981 to 2009. Not only is the financial regime which the firm faces endogenous, we also allow the regime to change over time via modelling efficiency using stochastic frontier analysis. The results reveal that a firm's constrained credit status changes with the improvement of its efficiency. Furthermore, the analysis reveals that financially constrained firm's investment is comparatively more sensitive to its cash flow. Moreover this sensitivity is statistically significant and is negatively related with corporate efficiency.

Keywords: Asymmetric information, financial constraints, switching regression.

JEL classification: C34, D92, G14, L21

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1. Introduction

The extent to which capital market imperfections influence firm corporate decisions such as investment is clearly an important issue given the role played by investment in economic growth. We investigate the role of financial frictions which may stem from capital market imperfections upon firm level investment in the UK. Fazzari, Hubbard, Petersen, Blinder, and Poterba (1988) were amongst the first to attempt to explain this relationship. They argued that the sensitivity of investment to internal funds should increase with the cost differential between internal and external funds - the so called monotonicity hypothesis. Typically, it has been common in the literature to classify firms a priori as to whether they are financially constrained or not based upon proxies of the cost differential. However, there are a number of issues with adopting such an approach.

Firstly, there is an endogenous selection problem as the classification criteria, i.e. which regime a firm belongs to (unconstrained v constrained), can be correlated with the level of investment or with firm-specific factors. Therefore, estimation results can be highly sensitive to the classification criteria and the threshold value chosen to split the sample into the two regimes. Secondly, there are potential problems of dynamic misspecification. This arises if the exogenously classified firms are kept in the same regime over the whole sample period, discarding the possibility that whether the firm is financially unconstrained or not may change over time. This will especially be the case when the extent of capital market imperfections depends on the general macroeconomic environment and becomes more important when the time period under consideration lengthens. We explicitly address these issues in the context of UK firms.

To tackle the above concerns our approach builds upon the work of Almeida and Campello (2007), whereby we employ an endogenous switching regression framework. This methodology allows us to model whether the firm is financially unconstrained or constrained and simultaneously a regime specific investment equation is estimated. This technique overcomes the endogenous selection problem i.e. prior assignment of a firm into a particular financial constraint category. Specifically, the approach we adopt explicitly models the probability that the firm faces a financially constrained regime. Furthermore, we depart from the current literature by allowing the regimes to change over time, hence attempting to alleviate the dynamic misspecification problem. We also concentrate on the changing pattern of investment-cash flow sensitivities with a variable measuring the extent of capital market imperfections based on the premise that investment-cash flow sensitivity should change with capital market imperfection if it is at all linked with these imperfections. For this, we use a stochastic frontier approach to compute an estimate of the corporate efficiency of a firm as an inverse proxy of agency costs by comparing a firm's actual Tobin's Q with its best performing benchmark Q (this approach follows Habib and Ljungqvist (2005)).

Using unbalanced panel data on 1122 UK firms listed on the London Stock Exchange over the period 1981 to 2009, we estimate a number of endogenous switching regression models. Our different model specifications strive to confront some of the challenges in examining the effects of capital-market imperfections upon investment decisions. In particular we consider the following: (i) whether efficiency affects the likelihood of being financially unconstrained or constrained; (ii) whether investment-cash flow sensitivity changes with efficiency; and (iii) whether the effect of efficiency on cash flow sensitivities is monotonic or non-monotonic.

We find that financially constrained firms are more likely to be smaller, younger, pay low dividends, have smaller collaterizable assets and less external debt. Moreover, financially constrained firms are worse off in terms of corporate efficiency and switch from constrained to unconstrained status when efficiency reaches a certain threshold. The results also reveal that financially constrained firm's investment is comparatively more sensitive to its cash flow, where this sensitivity is inversely related with corporate efficiency.

To summarise, the key contributions that we make in this paper are the following: (i) use of stochastic frontier analysis to compute corporate efficiency and then use this measure to classify firms as either constrained or unconstrained; (ii) avoid potential dynamic misspecification by allowing firms to switch regime (i.e. constrained or unconstrained) and the endogenous selection problem by simultaneously modelling the likelihood that the firm is financially constrained alongside regime specific investment equations; (iii) incorporate efficiency in the investment equation to clarify the role of cash flow in detecting the presence of market imperfections; (iv) the paper also contributes to the literature by focusing on the UK rather than the US and as far as we are aware, this is the first study of its kind to explicitly address the aforementioned concerns in the context of UK firms; and (v) the non monotonic effect of corporate efficiency on cash flow sensitivities sheds light on an area of debate in the literature Fazzari et al. (1988) and Kaplan and Zingales (1997).

This paper is structured into different sections as follows. Section 2 is a brief literature survey, section 3 describes the empirical methodology, section 4 introduces the data, variable definitions and descriptive statistics, section 5 presents the empirical results along with robustness analysis and finally section 6 concludes the paper.

2. Literature review

We firstly provide a brief review of how firm level investment is typically modelled in the literature, before looking at the role of financial constraints and how these may influence investment. Most empirical analysis doesn't consider the potential endogeneity of financial constraints and it is this literature that we add to. The next part of the literature review discusses how endogenous switiching regression analysis has been used in the literature to overcome this issue, which is the methodology we adopt in this paper (see section 3.2). Whilst it is common in the literature to focus upon fixed financial regimes, which can lead to dynamic misspecification problems, we allow firms to face time varying regimes by virtue of adopting stochastic frontier analysis whereby arguably efficiency is a measure of agency cost (see section 3.1). This is discussed in the final part of the literature review.

One of the most common approaches to explain firm investment is based upon Tobin's Q (Bond and Van Reenen, 2007). The Q-theory of investment stems from Tobin (1969) where average Q is defined as a ratio of the market value of existing capital to its replacement cost. Hayashi (1982) argues that average Q can adequately capture investment opportunities and explain investment demand. This occurs under the assumptions of perfect competition, constant returns, capital as the only quasi-fixed 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. Such specifications are generally known as extended Q models and are typically based upon average Q due to ease of measurement.

However, 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. They argue that this might lead to the estimated coefficients on Q being low and those on cash flow being high. Alternative approaches to using average Q are also evident in the literature, e.g. Whited (1992) and Ng and Schaller (1996) who estimate Euler equations.

The role of financial constraints and how these may impinge upon investment has also become topical. Fazzari et al. (1988) classify low-dividend paying US firms as more likely to face financial constraints and the investment level of such firms is found to be relatively more affected by the availability of cash flow compared to the high-dividend paying unconstrained firms. Hence, this provides 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). They classify those firms without access to surplus funds as financially constrained and their investment is likely to be less sensitive to cash flow.

The literature is broadly divided into two subsets. The deviation arises mainly because of the different ways used 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. For example, Devereux and Schiantarelli (1990), Gertler and Gilchrist (1994), Oliner and Rudebusch (1992), Kadapakkam, Kumar, and Riddick (1998) and Shin and Kim (2002) use size, age and patterns of insider trading. Alternatively, Hoshi, Kashyap, and Scharfstein (1991) and Shin and Park (1999) use the degree of industrial and bank affiliation. Other approaches have used firm bond ratings e.g. Whited (1992), or the degree of shareholding concentration e.g. Schaller (1993).

Using UK data, Guariglia (2008) 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.

A switching regression framework is adopted by Hu and Schiantarelli (1998) in order to address the problem of endogeneity of financial constraints. In more recent work, 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 for US manufacturing firms investment-cash flow sensitivity for the constrained firms increases with the tangibility of their assets, but not so for unconstrained firms. 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. We explicitly test this credit multiplier effect in our empirical analysis.

This paper follows the approach of Almeida and Campello (2007), but uses predicted corporate efficiency obtained from stochastic frontier analysis which is time varying. The advantage of this approach is that it enables firms to face different financial constraint status over time, hence avoiding the dynamic misspecification problem. We provide a distinctive complement to the existing literature by introducing corporate efficiency in the investment equation in another attempt to clarify the role of cash flow.[1] Recent developments consider efficiency measurement as tangential to the concept of (inverse) agency cost (Berger and Bonaccorsi di Patti, 2006), although a link between productive efficiency and agency costs can be traced back to Stigler (1976). Quader (2013) argues that the predicted corporate efficiency index is an inverse proxy of all market imperfection led inefficiencies which prevent the firms from value maximization. These inefficiencies can arise when shareholders take too risky projects and misrepresent the quality of the investment due to their conflict of interest with debtholders, or when managers misappropriate firm value due to their conflicts of interest with the shareholders. The first of these two costs is termed the agency cost of outside debt and the latter as the agency cost of outside equity and therefore, predicted efficiency is a broad measure of UK firms total agency costs as defined by Jensen and Meckling (1976).

3. Empirical methodology

The following two sub-sections explain how: (i) the corporate efficiency index is predicted, via stochastic frontier analysis; and (ii) the probability of a firm being in a particular regime is simultaneously estimated with a regime specific investment equation, via a switching regression model.

3.1. Stochastic frontier methodology

The intuition behind stochastic frontier analysis (SFA) is that each firm's shortfall from the frontier is an approximate indicator of the perceived firm inefficiency by the market.[2] Let production i.e. output, o_{it}, be a function of a set of covariates thought to influence production, G_{it}, unknown parameters to be estimated, ψ and an error term, ω_{it}.

$$o_{it} = G_{it}\psi + \omega_{it} \tag{1}$$

The stochastic production frontier differs to a standard production function in that there are two distinct error terms, one which is a symmetric random component capturing measurement error, random shocks (e.g. unanticipated technological change) and omitted variables, υ_{it}, and the other capturing inefficiency which is the shortfall from maximal output and hence has a negative sign, $-u_{it}$.

$$\omega_i = \upsilon_{it} - u_{it} \tag{2}$$

[1]There is evidence that the corporate governance environment under which UK companies operate is not disciplined by the market for corporate control (Short and Keasey, 1999, Franks, Mayer, and Renneboog, 2001, Köke and Renneboog, 2005). Moreover, 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) which may cause a significant degree of managerial discretion to be present in the UK firms, in comparison to the US and other European firms. This is consistent with the results of Bond, Elston, Mairesse, and Mulkay (2003) who find that the effects of financial constraints on investment are more severe in the UK than other European countries. Aguilera (2005) mentions reasons why corporate governance within the UK may have consequences for the rest of the industrialized world.

[2]SFA is the most widely accepted econometric technique for efficiency analysis (Greene, 2008).

The location of the frontier is allowed to shift by virtue of time varying covariates, G_{it}. Adopting a truncated normal distribution for the error gives more flexibility to the shape of the distribution of efficiency. Ignoring subscripts for brevity the truncated normal distribution for the error component u_{it} from equation (2) is given as follows:

$$f(u) = \frac{1}{\sqrt{2\pi}\sigma_u \Phi(\mu/\sigma_u)} e^{-\frac{(u-\mu)}{2\sigma_u^2}} \tag{3}$$

and is dependent upon two parameters μ and σ_u^2. Rather than treating μ as a constant, following Battese and Coelli (1995) we allow the parameter to vary by firm i and over time t with the determinants of μ_{it} being a linear function of exogenous factors expected to influence efficiency, H_{it}, and a corresponding set of parameters to be estimated δ, hence

$$\mu_{it} = H_{it}\delta \tag{4}$$

The covariates H_{it} are allowed to vary over time, thereby accommodating changes in a firm's position relative to the frontier over time and also capturing the dynamics of potential conflict between managers and shareholders. The log likelihood function for the SFA which jointly models the shortfall from maximal production, equations (1) and (2), and determinants of efficiency, equation (4), is given as follows:

$$\ln l = -n \ln \sigma - \sum \left(\frac{\omega_{it} + \mu_{it}}{\sigma}\right)^2 - n \ln \Phi(\mu_{it}/\sigma_u) + \sum \ln \Phi\left(\frac{\mu_{it}}{\sigma\lambda} - \frac{\omega_{it}\lambda}{\sigma}\right) \tag{5}$$

where Φ denotes the cumulative normal distribution function and $\lambda = (\sigma_u/\sigma_v)$, see Parmeter and Kumbhakara (2014).

3.2. Switching regression methodology

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. Moreover, investment and its relationship to the availability of internal funds can differ between regimes. The model is composed of the following system of three equations that are estimated simultaneously:

$$I_{1it} = X_{it}\beta_1 + \nu_{1it} \tag{6}$$
$$I_{2it} = X_{it}\beta_2 + \nu_{2it} \tag{7}$$
$$y_{it}^* = Z_{it}\alpha + \epsilon_{it} \tag{8}$$

Equations (6) and (7) are the structural equations that describe the investment behavior of firms in the alternative regimes. Equation (8) is the selection equation that determines a firm's propensity of being in a particular investment regime. X_{it} are the determinants of corporate investment and Z_{it} are the determinants of a firm's likelihood of being in a given regime at time t. β_1, β_2 and α are vectors of parameters and ν_1, ν_2 and ϵ are error terms. The observed investment, I_{it}, undertaken by firm i at time t, is defined as follows:

$$I_{it} = I_{1it}, y_{it} = 0 \ if \ y^*_{it} < 0 \tag{9}$$
$$I_{it} = I_{2it}, y_{it} = 1 \ if \ y^*_{it} \geq 0 \tag{10}$$

where y^*_{it} is a latent variable measuring the likelihood of being in the first or second regime and y_{it} is the observed criterion function which identifies the regime. Firms transfer between the regimes once y^*_{it} reaches the threshold value.[3]

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 zero mean and covariance matrix Ω, 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

$$\Omega = \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{1\epsilon} \\ \sigma_{21} & \sigma_2^2 & \sigma_{2\epsilon} \\ \sigma_{\epsilon 1} & \sigma_{\epsilon 2} & 1 \end{pmatrix} \tag{11}$$

The extent to which investment spending differs across the two regimes and the likelihood that firms are assigned to either regime are simultaneously determined. The model is estimated using Maximum Likelihood. Omitting it subscripts the log likelihood function for the switching regression model outlined in equations (6) to (11) is given by:

$$\ln l = \sum \left\{ \begin{array}{c} y \left[\ln\left(\Phi\left(\gamma_1\right)\right) + \ln\left(\phi\left(\nu_1/\sigma_1\right)/\sigma_1\right)\right] + \\ (1-y)\left[\ln\left(1-\Phi\left(\gamma_2\right)\right) + \ln\left(\phi\left(\nu_2/\sigma_2\right)/\sigma_2\right)\right] \end{array} \right\} \tag{12}$$

The cumulative normal distribution function and normal density function are denoted by Φ and ϕ respectively. Given that there are two regimes, $j = 1, 2$ the parameter γ_j is defined as follows:

$$\gamma_j = \frac{(Z\alpha + \rho_j \nu_j/\sigma_j)}{\sqrt{\left(1-\rho_j^2\right)}} \tag{13}$$

where $\rho_j = \sigma^2_{j\epsilon}/\sigma_\epsilon \sigma_j$, see Lokshin and Sajaia (2004) for full details.

The dependent variables in the two regime specific equations (6) and (7) are investment and the dependent variable in equation (8) is a classification variable which is binary. For the binary dependent variable in equation (8), the observations are coded as 1 (unconstrained) if their predicted efficiencies are above the 50th percentile value and 0 (constrained) otherwise. This is based on the assumption that highly efficient firms, or firms suffering less from agency cost related problems are most likely be financially unconstrained. The predicted efficiencies are given by the estimates of μ_{it} in equation (4) section 3.1.

[3] As the general macroeconomic conditions are the 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 remain unchanged for all firms. Possibly due to this likely occurrence Hovakimian and Titman (2006) and Almeida and Campello (2007) do not include time and firm/industry dummies in their selection equations.

4. Data

Data is obtained from the Worldscope Database.[4] The sample we use excludes all banks, life and non-life insurance, real estate, general financial, equity and non-equity investment instrument companies according to the FTSE/Dow Jones Industrial Classification Benchmark (ICB) codes which are adopted by the database. We also dropped all the observations with unexpected signs, i.e. negative revenue, assets or investment and all the other observations with missing values for the required variables. All firms with less than three consecutive years of observations for any of the required variables were also dropped. Finally, the dataset we use in our analysis is an unbalanced panel of 1122 firms operating in 33 different sectors with a minimum of 3 to a maximum of 29 consecutive years, yielding a total of 13183 firm-years. As we allow both entry and exit of firms over time, our empirical analysis using unbalanced panel data is expected to be free from any potential selection effects and survivor bias. All financial variables are deflated with the GDP deflator and all variables are winsored at the 1% and 99% level to omit extreme outliers. The latter rule is expected to eliminate observations reflecting very large mergers, extraordinary firm shocks, coding or severe measurement errors, e.g., Hovakimian and Titman (2006).

The following provides definitions of the variables used in the stochastic frontier and switching regression analysis. The dependent variable in equation (1), o_{it}, is the logarithm of the market value of assets, where market value is estimated as the book value of total assets minus the book value of equity plus market capitalization (Smith and Watts, 1992, Whited, 1992, Barclay and Smith Jr, 1995, Rajan and Zingales, 1995, Julio and Yook, 2012). The covariates, G_{it}, in this equation are as follows: (i) firm size which is defined by the natural logarithm of total sales; (ii) leverage which is calculated as the ratio of long term debt to total assets; (iii) capital expenditure defined as the funds used to acquire fixed assets; (iv) intangible assets defined as the ratio of intangible assets to total assets; (v) tangibility defined as the ratio of total tangible assets to total assets; (vi) dividend payouts given by the ratio of the total cash dividend paid to total assets; (vii) profit margin defined as the ratio of operating profits or earnings before interest, tax and depreciation to total assets; (viii) firm specific risk which is proxied by the standard deviation of the profit margin; and (ix) the asset base or the log of book value relative to total assets, which is a control factor from the log transformation of Tobin's Q.[5]

Covariates in the inefficiency equation (4), H_{it}, can include input variables in the stochastic frontier, provided the inefficiency effects are stochastic. In the following analysis we include firm size, leverage and firm risk (these variables are as defined above and are also included in G_{it}). Additional controls include firm age, given by the natural logarithm of the number of years that the firm is present in the data (as in Almeida and Campello (2007)), and a time trend to account for the possibility that the inefficiency effects may change linearly with respect to time.[6]

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

[5] A logarithmic transformation is commonly used in SFA in order to reduce skewness. Those variables with multiple zero observations are scaled by total assets instead of the log transformation to avoid losing observations following Nguyen and Swanson (2009).

[6] A detailed discussion of the variables and specification of the estimated stochastic frontier models can

The dependent variable in equations (6) and (7) of the switching regression model is investment which is calculated as a ratio of capital expenditure to total tangible assets following Hayashi (1982) and Cummins, Hassett, and Oliner (2006). We rely on the extended Q theory of investment model to identify the difference in investment behavior across groups of firms. Covariates in the investment equation given in X_{it} are defined as follows: (i) cash flow is the ratio of funds from operation to total assets; (ii) financial slack (Fin.slack) is calculated as the ratio of cash and short term investment to total assets; (iii) Tobin's Q is defined as the ratio of market value of assets to the book value of assets; (iv) market value efficiency (Mv.efficiency) is the corporate efficiency index derived from SFA, i.e. the predicted μ_{it} from equation (4);[7] and (v) tangibility as defined above.

Covariates in Z_{it} of equation (8), the probability of a firm being in particular regime in a given period, include financial slack, Tobin's Q, market value efficiency and tangibility as in X_{it} as well as controls for: (i) firm size defined as above; (ii) firm age defined as above;[8] (iii) the dividend payout defined as above; (iv) interest coverage ratio (Int.cov.ratio) which is the ratio of interest expense on debt to earnings before interest, taxes and depreciation; (v) short term debt (St.leverage) scaled by total assets; and (vi) long term debt (Lt.leverage) scaled by total assets. Table 1 reports means and distributional information for the variables separately for the full sample, and for firms by whether they are financially constrained or unconstrained. The predicted probability based upon the regime selection equation from the switching regression model, see Section 3.2, is used to allocate firms to a particular regime. When the predicted probability is above (below) the mean probability vector the regime is defined as financially unconstrained (constrained). [Insert Table 1 here]

Cash flow is a flow measure of internal liquidity and has a mean value of 3.9%, but there are 21% firm year observations with negative values. On the contrary, the stock measure of internal liquidity has a mean value of 15.8%. This stock measure doesn't have any negative observations, but there are firms with no such short term investment. The 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 Tobin's Q in our data is 12.7 which is close to the suggested cut-off point, this is expected to minimize the probable measurement error to some 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 a mean value of 10.4% compared to only 6.2% for short term debt. This divergence between the two sources of external financing is consistent throughout the sample. The flow measure of indebtedness, interest coverage ratio, has a mean value of 8.4% and supports the dependency of an average firm on external debt sources. The level of investment of an average firm is 27.9% with a median value of 20.5%. The classification of firm year observations into constrained and unconstrained categories based upon the predicted probability from the

be found in Quader and Dietrich (2014).

[7]Interestingly, based upon a comparison of the mean and variance over time efficiency is found to be largely time invariant and exhibits low variability. Furthermore, panel unit root tests based upon Im, Pesaran, and Shin (2003) show that efficiency is mean reverting.

[8]The results which follow are robust to defining age by the date the company was listed on the stock exchange. Full details are available upon request.

switching regression model suggests some apparent differences between the two groups in our data for example, financially unconstrained firms are likely to be larger, older, pay higher dividends and hold relatively higher levels of long term debt and tangible assets.

5. Empirical results

5.1. Stochastic frontier results

We estimate stochastic frontier models based on market value maximization approach, the results of which are shown in table 2.a. The results of estimating the frontier, equations (1) and (2), are shown in panel A, whilst panel B reports the estimates of inefficiency from equation (4). In model 1 we control for the same variables as in Himmelberg, Hubbard, and Palia (1999). Model 2 is our preferred specification where we extend the set of explanatory variables. Generally parameter estimates have the expected a priori signs in both models.

The value for the κ parameter, which is the intra-correlation between the two components of the error term in equation (2), i.e. $\kappa = \sigma_u^2/(\sigma_v^2+\sigma_u^2)$, is reported in the diagnostic statistics of table 2.a panel C. For model 2 the κ parameter reveals that 73% of total error variance is characterized by inefficiency or agency costs rather than white noise or random error. The null hypothesis that κ equals zero is rejected and this indicates that the inefficiency effects are stochastic and that the SFA specification leads to a likelihood gain. The LR test also supports this by rejecting the null hypothesis that inefficiency effects are absent and unrelated to the chosen explanatory variables in panel B, i.e. the H_{it}. Therefore, the results indicate the presence of inefficiency effects or agency conflicts occurring on average in UK firms over the sample period.

We will use the predicted market value efficiency measure, μ_{it}, from equation (4) calculated from model 2 for our analysis later specifically to define regimes. The mean efficiency predicted from this model is 74.5%, see table 2.b, 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. Full distributional information for the efficiency term is presented in table 2.b and figure 1. [Insert Table 2 and Figure 1 here]

5.2. Switching regression results

We estimate two different switching regression models in line with the existing literature. In model 1, we include efficiency and its interaction term with cash flow in the investment equations, i.e. as additional covariates in X_{it}. The reason for doing this is to check the magnitude and direction of investment-cash flow sensitivity and whether this changes with corporate efficiency. In model 2, we additionally include in X_{it} asset tangibility and its interaction with cash flow in the investment equations in a similar attempt to check the potential changing pattern of investment cash flow sensitivity with tangibility, following Almeida and Campello (2007).

5.2.1. Effect of efficiency on investment cash flow sensitivity

In this subsection we focus upon the analysis of model 1. The results are composed of three parts. The selection equation is presented in table 3.a which determines a firm's likelihood of being in a constrained or unconstrained regime, whilst table 3.b shows two separate investment equations for constrained and unconstrained firms which reveals how firm investment behavior differs across the two groups. A positive coefficient for any variable in the selection equation indicates that firms are more likely to be in the unconstrained regime. The relationship will be reversed for any selection variable having a negative coefficient.

The results support 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 opportunities. A priori we would expect a negative coefficient for financial slack since financially constrained firms have an incentive to hold short term liquid assets. Whilst the estimated coefficient for this variable has a positive sign, it is statistically insignificant. Tangible asset's have a positive effect on firm's credibility to external financiers. 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). The two stock measures of indebtedness, short term and long term leverage, and also the corresponding flow measure, the interest coverage ratio, each have positive and statistically significant coefficients. These results indicate that firms with a high level of external debt are less dependent on internally generated funds possibly due to their high debt capacity or reduced agency cost problems. In other words, these firms may find it easier to convince lenders to provide them with external credit on the strength of their collaterizable assets and proven track record, this is consistent with Hovakimian and Titman (2006).[9] A firm's efficiency has a significant effect on the credit status of the firm. The more efficient a particular firm is, or the less severe the agency cost problems, the lower is the firm's probability of facing constrained financial status.

Table 3.b represents the results of the regime specific investment equations estimated simultaneously with the selection equation. The results reveal that investment behavior is significantly different between the constrained and unconstrained regimes. The coefficients of Tobin's Q are positive in the two regimes showing that firms with better investment opportunities 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 the magnitudes of the estimated coefficients for these two variables are larger in the constrained regime. This implies that for those firms which are financially constrained investment is more sensitive to internal liquidity due to the difficultly of easily switching between internal and external finance.

The results reveal that higher firm efficiency, i.e. lower agency costs, is inversely related with investment. This might be due to firms which suffer from agency conflicts having a tendency to over-invest, i.e., invest in negative net present value (NPV) projects, see Jensen (1986). There are a number of factors that may make a firms investment policy depend on its financial position. The existence of post-contract asymmetric information between

[9]High levels of external debt can make firms financially constrained as a result of greater exposure to bankruptcy risk. Hence, we have estimated models incorporating the squared values of indebtedness. This analysis revealed a positive and monotonic relationship throughout the whole distribution of short term debt; up to the 95th percentile of long term debt; and that the results of the accompanying investment equations were robust. Given the finding of monotonicity, in the analysis which follows we report specifications excluding the quadratic terms in debt.

shareholders and bondholders, Jensen and Meckling (1976) and Myers (1977), and/or pre-contract asymmetric information between current and prospective shareholders may lead to the rejection of some investment projects which have positive NPV, i.e. under-investment, Myers and Majluf (1984). Conversely, negative NPV investment projects might end up being undertaken - the problem of over-investment, Jensen (1986). Managers over-investment in self-serving projects may take any of the following forms: (i) empire building (Jensen, 1986, 1993, Shleifer and Vishny, 1997); (ii) perquisite consumption (Jensen and Meckling, 1976); (iii) diversifying acquisitions (Morck, Shleifer, and Vishny, 1990); and (iv) subsidizing poorly performing divisions using the cash generated from successful ones instead of returning the cash to shareholders (Berger and Hann, 2003, Jensen and Meckling, 1976, Lamont, 1997).

Furthermore, it is evident in the literature that such opportunities are more likely to arise in those firms with poor governance. Where poor governance may be characterized by the absence of effective monitoring, disciplining mechanisms and hence a significant degree of managerial discretion, arguably as in case of the UK firms, which allow the entrenched managers to pursue their own self-interest and expropriate wealth from shareholder.[10] Previous empirical research also shows that improvements in the internal governance mechanism have been effective in reducing agency cost, which limits the potential for sub-optimal managerial behavior (Gillan, 2006). We earlier argued that the corporate efficiency index is an inverse proxy for UK firms total agency costs, as defined by Jensen and Meckling (1976), and that the least efficient firms are found to be financially constrained. Therefore, as corporate efficiency improves or managerial entrenchment becomes limited, their investment decisions may become more restrictive towards long term and sustainable value maximization projects, thus making investments negatively related to corporate efficiency.[11]

Interestingly, the aforementioned inverse relationship is only evident for financially constrained firms. Such contrasting behavior between the two groups of firms may be explicated by the cost and revenue effect proposed by Cleary, Povel, and Raith (2007). This along with the perceived effect of efficiency on firms' credit status suggest important implications. Firms are financially constrained at low levels of efficiency, but their investment becomes less and less sensitive to the availability of internal funds as their level of corporate efficiency increases. Higher efficiency makes the agency conflict less severe and enables the firms' managers to take optimal financing and investment decisions, potentially earning higher revenue for these firms. This may switch on the "revenue effect" as higher revenue is subsequently expected to lower the firms' risk of default. Therefore, the hindrance to constrained firms' access to external financing sources may become less acute with improvements in their efficiency making them less intensely dependent on internally generated funds. This is consistent with the findings of Agca and Mozumdar (2008), Attig, Cleary, El Ghoul, and Guedhami (2012) and Bond and Söderbom (2013). Once these firms' efficiency reaches 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.

[10] Pawlina and Renneboog (2005) confirm that investment is strongly cash flow-sensitive for firms listed on the London stock exchange and their analysis supports the Jensen (1986) over-investment hypothesis.

[11] Using a large sample of UK firms over the period 1999-2005 Florackis and Ozkan (2009) have shown that firms with high levels of managerial entrenchment exhibit higher agency costs, i.e. sub-optimal managerial behavior is positively related with agency costs.

Subsequently they require higher borrowing, higher repayment costs and consequently this results in a higher risk of default. This "cost effect" may be responsible for their investment becoming increasingly sensitive to cash flow as efficiency increases further. [Insert Table 3 here]

Overall, our findings indicate a non monotonic effect of corporate efficiency on cash flow sensitivities. At lower levels of efficiency, firms are financially constrained and their investment cash flow sensitivity decreases with efficiency. When efficiency reaches a certain threshold, 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 2. The level of efficiency where the status changes from constrained to unconstrained can not be observed, however, 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. Similar to the findings of Agca and Mozumdar (2008), our results support the idea that higher sensitivity of investments to cash flow for the financially constrained firms shouldn't be decreasing with improvements in efficiency if that is solely generated as a consequence of measurement error. [Insert Figure 2 here]

5.2.2. Credit multiplier effect

This section examines the credit multiplier effect focusing upon the estimates of model 2 which in addition to the covariates included in model 1 also incorporates asset tangibility and its interaction with cash flow in the investment equations, following the approach of Almeida and Campello (2007). The results of the selection equation of model 2 shown in table 3.a are almost identical to that of model 1. Firms that are larger, older, have a lower market-to-book ratio, lower financial slack, pay high dividends, are those which are more efficient and have more tangible assets. Such firms are also more likely to operate in the unconstrained regime. The possibility of highly levered firms' facing unconstrained credit status also remains apparent in the analysis. The findings of the two regime specific investment equations of our second model shown in table 3.b are also consistent with those of model 1. Firms operating in the constrained investment regime demonstrate higher sensitivity to the two measures of internal liquidity. The changing credit status of firms with efficiency is also evident. Most importantly, the constrained firms' investment cash flow sensitivity also decreases with efficiency in this extended model specification. However, the increase in the investment cash flow sensitivity with efficiency for the unconstrained firms is statistically insignificant.

Making use of the Kiyotaki and Moore (1997) credit multiplier model, Almeida and Campello (2007) find that asset tangibility amplifies the effect of an exogenous income shock on the investment spending of financially constrained firms only and raises their investment-cash flow sensitivity. They argue that these firms are better able to increase their collateral value by investing more in pledgable assets following a positive income shock. This 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 longer affect their investment-cash flow sensitivity. We find a positive and significant effect of tangibility on the investment cash flow sensitivity for both groups of firms. Not only that, the estimated coefficients suggest that the credit multiplier mechanism is stronger for the unconstrained firms in the sample who are also more likely to have high tangible assets. It may be argued that such a positive relationship between cash flow and external financing should be particularly strong for those firms with high tangible assets. This is because new investment in more collateralizable assets could potentially enhance their credit capacity more than what is observed for firms with less tangible assets (Almeida and Campello, 2010). Hence, the resulting relationship between tangibility and investment cash flow sensitivity is found to be monotonic in UK firms.

5.3. Robustness analysis

We conduct a series of robustness checks in order to check the sensitivity of the results. It could be deemed problematic to create the initial classification variable (dependent variable, y^*_{it}) in the selection equation using efficiency and at the same time include efficiency as a covariate in the investment equation. In order to tackle this issue, we estimate both models excluding efficiency from the Z_{it} vector. The results reported in table 4 are found to be robust to this change in the model specification. The effect of efficiency on firm's credit status is still apparent and the non monotonic relationship between efficiency and investment cash flow sensitivity prevails. [Insert Table 4 here]

Following Hu and Schiantarelli (1998), we also include the sales-to-capital ratio as an additional regressor in the 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. The results are reported in table 5. As expected, the 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 remains the same as that found in specifications excluding sales. Investment continues to show higher sensitivity to our two internal liquidity measures for the constrained firms. Also there is variation of the investment cash flow sensitivity with efficiency and with tangibility. For both interactions the divergence between the two regimes persists. [Insert Table 5 here]

The models estimated so far include all contemporary variables, both in the selection and the investment equation. However, certain variables e.g. cash flow, financial slack, Tobin's Q in the investment equation may create endogeneity problems. To account for that, we re-estimate the two models replacing the contemporary explanatory variables in the investment equation by their one year lagged values keeping variables in the selection equation the same as before. In this case, the selection equation still determines whether the contemporary investment belongs to the constrained and unconstrained regime, but investment in the current period is now explained by one year lagged explanatory variables. The outcomes are reported in table 6 and are consistent with the results already obtained. Moreover, the finding that corporate efficiency is inversely related with firm investment in the constrained regime but that the association is positive and statistically significant in the unconstrained regime is consistent with figure 2 and non-monotonicity. [Insert Table 6 here]

As the predicted market value efficiency is skewed as can be seen from figure 1, we have also experimented with alternative cut off thresholds required for the switching regression, specifically using either 60th, 70th or 80th percentile values of μ_{it} as the initial cut-off points.

Hence, this redefines the regime classification threshold, i.e. the level determining whether a firm is constrained or unconstrained. However, the results are not sensitive to these alternative specifications.[12] This confirms that the two regimes are indeed endogenously selected by the model, no matter how we create the initial exogenous classification.

We have also estimated investment equations based upon ex ante selected constrained and unconstrained regimes, i.e. exogenously determined. We rely on the predicted corporate efficiency index from the stochastic frontier analysis and also firm size as our pre classification variables. In both cases firm-years falling below the 50th percentile of the distribution of the corresponding efficiency and size of all firm years are ranked as financially constrained. Table 7 shows the results based upon Ordinary Least Squares estimation, where sector and year dummies are included as regressors and standard errors are clustered by firm. In table 8, GMM estimates (Arellano and Bond, 1991) are provided which include a full set of year dummies both as regressors and instruments.[13] In addition, selected lagged levels of the explanatory variables are used as instruments for the first differenced equations. These alternative estimators bring no significant qualitative changes to our main inferences, being consistent with our earlier findings, that is there is a non-monotonic U shaped relationship between investment cash flow sensitivity and corporate efficiency. [Insert Tables 7 and 8 here]

6. Conclusion

This paper 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. We make a number of contributions to the literature. We allow the financial regime that the firm faces to change over time, thereby avoiding the dynamic misspecification problem, which is a novel addition to the literature. We attempt to alleviate the endogeneity issue by adopting an endogenous switching regression model allowing the regime to be time varying. This framework is then applied to UK firm level data. 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. The 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. Although the results of the empirical analysis are consistent with the existing literature and are qualitatively the same across alternative estimators in terms of non-monotonicity - i.e. maximum likelihood switching regression model, OLS and GMM - not surprisingly the point estimators differ substantially due to the bias and potential mis-classification associated with conventional reduced form methods used in the literature. An implication of our findings for researchers is that, cross-sectional variation in the investment sensitivity to internal finance may still be

[12] Full results are available upon request.

[13] A disadvantage of the data is that we do not have information on other potential influencing variables (i.e. PIN, corporate governance, analyst behaviour, and voluntary asset sales). The GMM approach may help alleviate this to some extent since firm specific influences are controlled for.

interpreted as a consequence of capital market imperfections.

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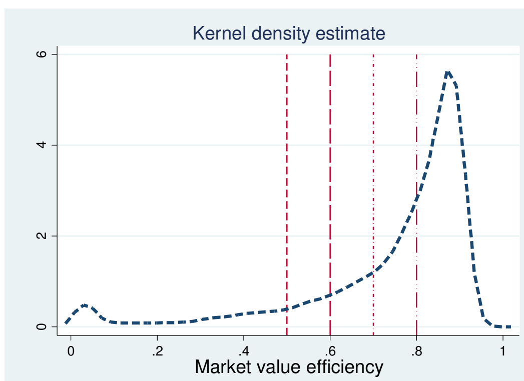
Figure 1: **Kernel density estimation of the predicted market value efficiency**



Notes: This figure shows the kernel density estimation of the predicted market value efficiency, i.e. μ_{it} from equation (4), and reveals negative skew in its distribution (also see table 2.b).

Figure 2: **Non monotonic relationship between investment cash flow sensitivity and efficiency**

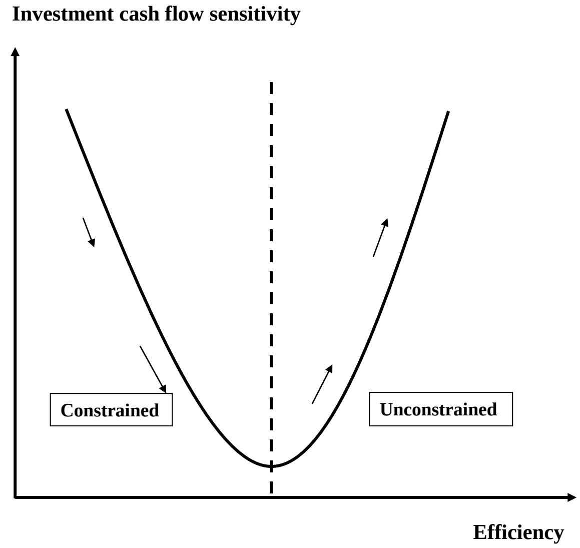


Table 1: **Descriptive Statistics**

	Full Sample		Constrained		Unconstrained	
	Mean	SD	Mean	SD	Mean	SD
Market value	11.83	2.230	10.94	1.923	12.73	2.156
Investment	0.279	0.238	0.371	0.282	0.186	0.128
Cash flow	0.039	0.201	-0.023	0.251	0.099	0.097
Tobin's Q	2.033	1.864	2.474	2.377	1.592	0.953
Tangibility	0.289	0.239	0.127	0.123	0.453	0.213
Intangible asset	0.141	0.212	0.226	0.251	0.055	0.111
Firm risk	0.135	0.145	0.188	0.174	0.082	0.078
Profit margin	0.053	0.277	-0.033	0.347	0.138	0.133
Asset base	11.35	2.280	10.31	1.987	12.38	2.074
Size	10.921	3.243	9.458	3.474	12.38	2.166
Age	2.114	0.862	1.85	0.884	2.379	0.751
Dividend	0.021	0.024	0.014	0.022	0.028	0.023
St.leverage	0.062	0.089	0.054	0.091	0.071	0.086
Lt.leverage	0.104	0.135	0.071	0.124	0.138	0.137
Fin.slack	0.158	0.184	0.226	0.224	0.091	0.093
Int.cov.ratio	0.084	0.273	0.037	0.265	0.13	0.273
No of obs.		13183		6592		6591

Notes: 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. SD denote standard deviation. All financial variables are deflated with a GDP deflator and all regression variables are winsored at the 1% and 99% level in order to omit extreme outliers. Firms are defined as either financially constrained or unconstrained based upon the predicted probability from the selection equation in the switching regression model. When the predicted probability is above (below) the mean probability vector the regime is defined as financially unconstrained (constrained).

Table 2: **Stochastic frontier analysis**

Table 2.a: **Market value frontier and inefficiency**

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
C: Diagnostics						
σ^2	0.552	0.012	46.47	0.588	0.014	42.22
κ	0.663	0.011	58.26	0.734	0.010	73.66
No of firms	1122			1122		
No of observations	13183			13183		
Log likelihood	-9592.24			-8997.12		
LR test	1041.69[1]			1119.40[2]		

Notes: These market value frontiers have been estimated with sector and year dummies. $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\kappa = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$.
[1,2] Likelihood ratio tests for the null hypothesis that $\delta_0 = \delta_1 \cdots = \delta_7 = 0$, critical value is 20.97 at the 1% level of significance.

Table 2.b: **Summary statistics for market value efficiency**

	Mean	SD	Skewness	Min	Q1	Median	Q3	Max
$Mv.efficiency_{model1}$	0.752	0.193	-2.087	0.007	0.704	0.822	0.877	1
$Mv.efficiency_{model2}$	0.745	0.201	-2.005	0.006	0.696	0.821	0.876	1

Notes: This table gives mean and distributional information for our predicted market value efficiencies (Mv.efficiency), i.e. the estimates of μ_{it} from equation (4) for models 1 and 2 in Table 2.a.

Table 3: **Switching regression models with market value efficiency**

Table 3.a: **Selection equations**

	Model 1	Model 2
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

Notes: This table gives the maximum likelihood estimation results of our two switching regression models. The selection equation determines a firm's likelihood of being in a constrained or unconstrained regime, where the dependent variable is coded 1 for the unconstrained investment regime and 0 for the constrained regime. 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.b: **Investment equations**

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

Notes: The investment equations are estimated with sector and year dummies. Standard errors are clustered at the firm level. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively and standard errors are in parentheses.

Table 4: **Switching regression models excluding efficiency from the selection equation**

Table 4.a: **Selection equations**

	Model 1	Model 2
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

Notes: This table gives the maximum likelihood estimation results of our two switching regression models. The selection equation determines a firm's likelihood of being in a constrained or unconstrained regime, where the dependent variable is coded 1 for the unconstrained investment regime and 0 for the constrained regime. 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 4.b: **Investment equations**

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

Notes: The investment equations are estimated with sector and year dummies. Standard errors are clustered at the firm level. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively and standard errors are in parentheses.

Table 5: **Switching regression models with sales-to-capital ratio**

Table 5.a: **Selection equations**

	Model 1	Model 2
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

Notes: This table gives the maximum likelihood estimation results of our two switching regression models. The selection equation determines a firm's likelihood of being in a constrained or unconstrained regime, where the dependent variable is coded 1 for the unconstrained investment regime and 0 for the constrained regime. 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 5.b: **Investment equations**

	Model 1		Model 2	
	Unconst.	Const.	Unconst.	Const.
Cash flow	0.052	0.146**	0.061	0.174***
	(0.037)	(0.058)	(0.037)	(0.059)
Sales/Capital	0.002***	0.002***	0.001***	0.002***
	(0.0001)	(0.0001)	(0.0001)	(0.0002)
Cash flow*Mv.efficiency	0.168***	-0.102	0.050	-0.246***
	(0.048)	(0.082)	(0.050)	(0.082)
Cash flow*Tangibility			0.357***	0.266***
			(0.063)	(0.086)
Fin.slack	0.106***	0.151***	0.058***	0.088***
	(0.013)	(0.022)	(0.013)	(0.022)
Tobin's Q	0.017***	0.030***	0.016***	0.030***
	(0.001)	(0.002)	(0.001)	(0.002)
Mv.efficiency	-0.010	-0.543***	-0.011	-0.518***
	(0.018)	(0.028)	(0.018)	(0.028)
Tangibility			-0.147***	-0.201***
			(0.013)	(0.030)
Constant	0.154***	0.598***	0.197***	0.636***
	(0.019)	(0.061)	(0.019)	(0.061)

Notes: The investment equations are estimated with sector and year dummies. Standard errors are clustered at the firm level. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively and standard errors are in parentheses.

Table 6: **Switching regression models controlling for endogeneity**

Table 6.a: **Selection equations**

	Model 1	Model 2
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

Notes: This table gives the maximum likelihood estimation results of our two switching regression models. The selection equation determines a firm's likelihood of being in a constrained or unconstrained regime, where the dependent variable is coded 1 for the unconstrained investment regime and 0 for the constrained regime. 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 6.b: **Investment equations**

	Model 1		Model 2	
	Unconst.	Const.	Unconst.	Const.
Cash flow [t-1]	0.079**	0.226***	0.031	0.168***
	(0.036)	(0.056)	(0.040)	(0.055)
Cash flow*Mv.Efficiency [t-1]	0.120**	-0.297***	0.083	-0.273***
	(0.048)	(0.077)	(0.054)	(0.069)
Cash flow*Tangibility [t-1]			0.350***	0.239***
			(0.070)	(0.079)
Fin.slack [t-1]	0.151***	0.192***	0.071***	0.069**
	(0.014)	(0.022)	(0.014)	(0.024)
Tobin's Q [t-1]	0.019***	0.017***	0.016***	0.015***
	(0.001)	(0.002)	(0.001)	(0.002)
Mv.Efficiency [t-1]	0.033**	-0.276***	0.034*	-0.219***
	(0.016)	(0.029)	(0.018)	(0.035)
Tangibility [t-1]			-0.222***	-0.377***
			(0.013)	(0.036)
Constant	0.124***	0.213***	0.187***	0.197***
	(0.018)	(0.044)	(0.019)	(0.047)

Notes: The investment equations are estimated with sector and year dummies. Standard errors are clustered at the firm level. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively and standard errors are in parentheses.

Table 7: **Investment equations for ex ante selected regimes using OLS**

	Efficiency		Size	
	Unconst.	Const.	Unconst.	Const.
Cash flow	0.184***	0.300***	0.144***	0.323***
	(0.030)	(0.050)	(0.032)	(0.057)
Cash flow*Mv.efficiency	0.306***	-0.180***	0.387***	-0.226***
	(0.047)	(0.047)	(0.045)	(0.079)
Cash flow*Tangibility	0.187**	0.188*	0.238***	0.232*
	(0.074)	(0.104)	(0.074)	(0.129)
Fin.slack	0.114***	0.241***	0.032**	0.173***
	(0.014)	(0.021)	(0.014)	(0.022)
Tobin's Q	0.011***	0.003	0.008***	0.001
	(0.002)	(0.002)	(0.001)	(0.002)
Mv.efficiency	-0.334***	-0.526***	-0.388***	-0.509***
	(0.028)	(0.055)	(0.027)	(0.058)
Tangibility	-0.200***	-.374***	-0.198***	-0.274***
	(0.012)	(0.036)	(0.009)	(0.034)
Constant	0.463***	0.562***	0.553***	1.180***
	(0.030)	(0.065)	(0.024)	(0.052)
R^2	0.394	0.280	0.337	0.280
N	6592	6591	6592	6591

Notes: The investment equations are estimated with sector and year dummies. Standard errors are clustered at the firm level. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively and standard errors are in parentheses.

Table 8: **Investment equations for ex ante selected regimes using GMM**

	Efficiency		Size	
	Unconst.	Const.	Unconst.	Const.
Cash flow	0.134***	0.155****	0.133***	0.167**
	(0.035)	(0.060)	(0.034)	(0.060)
Cash flow*Mv.efficiency	0.094**	-0.264***	0.096**	-0.256***
	(0.045)	(0.084)	(0.045)	(0.084)
Cash flow*Tangibility	0.229***	0.1165***	0.237***	0.150*
	(0.053)	(0.034)	(0.053)	(0.093)
Fin.slack	0.031***	0.107***	0.036***	0.055**
	(0.017)	(0.033)	(0.016)	(0.031)
Tobin's Q	0.009***	0.017***	0.010***	0.019***
	(0.001)	(0.002)	(0.001)	(0.002)
Mv.efficiency	0.017	-0.306***	0.017	-0.313***
	(0.014)	(0.032)	(0.014)	(0.031)
Tangibility	-0.135***	-0.288***	-0.136***	-0.277***
	(0.009)	(0.037)	(0.009)	(0.037)
Hansen's J statistics	0.425	0.367	0.235	0.318
N	6072	5923	6277	5718

Notes: Estimates include a full set of year dummies both as regressors and instruments. In addition estimates include selected lagged levels of the explanatory variables as instruments for the first differenced equation. ***, ** and * indicate significance at the 1%, 5% and 10%, level respectively and standard errors are in parentheses.