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Estimating Investment without Asset Prices - European Evidence

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Estimating Investment without Asset Prices - European Evidence

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Instructor: Matti Keloharju

Student: Nguyen Tuan Anh

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PHASE 2

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1. Introduction

1.1 Motivation for the research

For past few decades, Tobin's Q has been widely used as one of the most important determinants in assessing any investment behaviors. In fact, a majority of corporate behavior and investment studies has always started off with basic assumption about its simple homogenous linear quadratic model. However, despite the common popularity, it is also largely acknowledged that the application of Tobin's Q in these models is extremely limited due to a variety of restrictions and constrains it imposed on.

During my search for a fresh approach that can avoid the limitation caused by the use of Tobin's Q while still being capable of correctly predicting corporate investment behavior we came across Gala and Gomes (2012) study. Their new investment model with the inclusion of firm size and sales/ cash flows as the key state variables has proved to be far superior to the traditional investment model based on Tobin's Q linear quadratic equation. Overall, Gala and Gomes's parsimonious state variable polynomial is able to account for more than four times as much as Tobin's Q of the total explained variation in investment.

In addition, while most of previous studies have been focused on approximating the marginal q with various measurable specifications, Gala and Gomes bypass this by directly approximating the optimal investment model. Thanks to this approach, their model requires very few restrictions on functional forms of stochastic discount factor, operating profit and adjustment costs (Gala and Gomes, 2012) as opposed to other Tobin's Q based-models. Consequently, this model can be easily estimated by standard OLS regression instead of nonlinear GMM techniques.

Inspired by what Gala and Gomes has been able to achieve with their new investment model, I attempt to replicate their current study on an entirely different set of markets and relatively different period. My objective is to see whether their model can still be applicable when being test under a completely new environment in which regulation and other macro/ external factors significantly differ from the one in the States.

1.2. Research gap and contribution

Gala and Gomes' newly designed model has been so far able to deliver consistently significant results. However, it seems to have not been tested anywhere except in the States. This gives me an incentive to test the quality of their model on some major European markets. The result of my study, if as strong, would provide addition empirical evidence on the effectiveness of their model in explaining the variation in investment rate. The supported model could then be further developed to accommodate for more complex environment, which might be of high interest in some other related study.

Even though the European market, which is the focused targets in this study, is relatively less developed than the US market, our initial expectation is still to achieve more or less similar results to that of the two authors. Any positive result from our study would undoubtedly help strengthen and lend additional support to the validation of Gala and Gomes' model.

1.3. Limitation of the study

The focus of my paper is on European markets of which data availability are somewhat limited. The lack of sufficient amount of data may render some of the results insignificant albeit still possibly meaningful. Because of this, the time span used in the study is also much shorter, compared to that of original paper. I expect these limitations would have certain impact on the final outcome of my study.

1.4. Structure of the study

The rest of my paper is organized as follows. In section 2, I review relevant literature on Tobin Q, its main applications and connection to my study. Hypotheses are developed in section 3. Section 4 and 5 are reserved to present the sample selection and methodology respectively. The results are reported in section 6 and section 7 conclude and suggest possible directions for future research.

2. Literature Review

2.1. Tobin's q theory

The famous Tobin's q theory is a theory of investment behavior which was first developed by James Tobin (1968). James suggested that the rate of investment is a function of q, the ratio of the market value of new additional investment goods to their replacement costs. This q is also known as the marginal q.

In reality, the marginal q, however, is not directly observable. The problem persisted until Hayashi (1982) came up with a new formation of q which is later known as average q. The new q is computed as the ratio of the market value of existing capital to its replacement cost. The biggest advantage average q holds over marginal q is that average q is quite often observable. However, Hayashi also pointed out that average q is only equal to marginal q if the firm is a price taker with constant returns to scale in both production and installation. If the firm is a price maker, then average q is higher than marginal q by what is called the monopoly rent.

According to the economic theory, the value of q should be equivalent to 1. If, however, the value of q somehow exceeds this value, it means additional investment is recommended since the profit generated is higher than the cost of using firm's assets. On the contrary, if q values less than 1 the firm should consider selling some of its assets since they are probably underutilized. The main idea is that by selling off assets that are not directly related to profit generation, the firm will move closer toward a state of equilibrium. The ideal state is where q is approximately equal to 1 in which the firm is in equilibrium.

2.2. Applications of Tobin's q theory

Since the birth of Tobin's q theory, many researchers have attempted to use it as a proxy variable for many corporate phenomena, mostly firm's intangible value. This is based on assumption that the long run equilibrium market value must be equal to the replacement value of its assets, given a q-value close to 1.

The very first authors that thought of using q as a proxy variable in their investment model were Lindenberg and Ross (1981). They used q as a measure of the capitalized value of monopoly of rent to examine the relationship between accounting and financial market data, which then helped determine the extent, distribution and history of monopoly and quasi-rent in the industrial sector.

Some other authors, however, believed that Tobin’s q is a good measure for research and development (R&D) investment in a firm. For instance, Cockburn and Griliches (1988) associated q with knowledge capital in the form of accumulated stock of R&D and patents in their attempt to examine the stock market valuation of firm's innovative activities. Megna and Klock (1993) closely followed the footstep of two previous authors in using q as a proxy for R&D, albeit with some additional adjustments, to assess the impact of intangible capital in the semiconductor industry. It was also Megna and Klock (2000) who expanded their study further in the wireless telecommunications industry white still using q as a proxy for intangible capital. Their results further reinforced the significance of stocks of intangible capital in determining Tobin's q value in this particular industry.

In another related study, Bharadwaj and Konsynski (1999) used Tobin q as a proxy for firm’s performance to assess the effect of information technology (IT) investment in the firm. They argued that despite the increasing evidence that information technology assets contribute to firm performance and future growth potential of the firms, there were only a few studies dedicated to address the relation between firm performance and IT investment. The result of their study showed that IT investment had a significant positive association with Tobin's q value which is an indication of IT significant contribution to firm's future performance potential.

2.3. Tobin’s q’s limitations & calculation methods

By definition, we would need accurate measures of market value of firm's assets and replacement cost of a firm's assets in order for q to be meaningful. While it might be possible to obtain true market value of firm assets by summing up the market value of the securities a firm has issued, such as stocks or bonds, it is much more difficult to get an accurate estimate of the replacement cost of its assets unless the used assets are still traded in the market. And even if that is the case, other complications such as the amount of time already in use and outdated technology might affect their current value.

Given the nature of it, estimating accurate value of firm's intangible assets is another hindrance one has to overcome in order to obtain a fair value of q. As a result, many researchers tend to ignore the replacement cost of intangible assets when computing q, which then often leads to an inaccurate measure of q.

Nowadays several of methods have been invented to overcome these difficulties. Standing out the most are computational costly approach and simple approach. Representative of the former approach is Lindenberg and Ross (1981). Their method is quite simple. The market price is computed as the sum of each traded financial claim of the firm while the replacement cost is estimated by adjusting the book value of assets for cumulative inflation and depreciations which occurs between the time fixed assets are placed in service and present. Chung and Pruitt (1994) is the representative of second approach in which only a comparatively small set of financial statement data with minimal adjustment is used. In fact, the latter approach involves using a simple formula that requires financial and accounting information mostly available from any database:

$$Tobin's\ q = \frac{MVE + PS + DEBT}{TA}$$

Where MVE is the product of a firm's share price and the number of common share outstanding. PS is the book value of the firm's preferred stocks. DEBT is the value of the firm's short-term liabilities net of its short-term assets and plus the book value of the firm's long-term debt. TA is the book value of the total assets of the firm.

In this study, I use the second approach to calculate the q ratio because of its simplicity and availability of data needed.

2.4. Criticisms on the use of Tobin's q based model

The Tobin's q theory has become the core and framework for many studies on the corporate behavior and aggregate investment up to date. The common perception that Tobin's q is the sufficient statistic measure to assess the investment behavior has been strongly supported in studies of many notable researchers who based their investment regression model on the linear quadratic version of Tobin's q (Blundell, et al., 1992, Fazzari, et al., 1988, Lang, et al., 1989) Depending on the purposes and objectives of the studies, the q- based investment regression is slightly modified by various ad hoc measure of cash flow to test, for instance, the significance of financial constraints, effect of corporate governance and market efficiency.

Many studies later on, however, have proved that q is not an appropriate and precise measure for assessment of such corporate behaviors. In fact, the explicit assumption about it being a homogenous linear quadratic model, which initiated its use in the first place, is even considered misspecified. Gomez (2001), Cooper and Ejarque (2003) and Abel and Eberly (2012) attributed this misspecification to technological and financial frictions such as market power or decreasing returns to scale in production. The cause could also come from the inhomogeneous cost of investment and inhomogeneous cost of external financing as specified in Cooper and Haltiwanger (2006) and Hennessy and Whited (2007) studies. Despite all its shortcomings, the linear q- based investment regression is still the main model that has been repeatedly used in most of the studies about corporate behaviors.

The persistent use of Tobin's q has been more severely criticized by Erickson and Whited (2000, 2006 and 2012) in one of their most recently related studies about q. In the light of their findings, they concluded that "Tobin's q contains a great deal of measurement error because of a conceptual gap between true investment opportunities and observable measures".

2.5. Gala and Gomez's Study

Recognizing the limitations of Tobin's q in correctly predicting investment behaviors, Gala and Gomes (2012) have invented a new model that could help overcome the problems that many prior q-based studies ran into. Their idea is quite simple. Based on the fact that the optimal investment policy is always a function of key state variables of the firm, they decided to approximate them at a low order polynomial. The biggest advantage of this method is that many of the state variables are directly observable or can be constructed from observables under fairly general conditions, unlike marginal q.

One of major innovations in their study lies in the inclusion of firm size and sales/ cash flows as the key state variables for optimal investment. It's considered an innovative step because almost none of the prior studies have ever thought of using these variables for such a role. For instance, firm size, despite its popularity, is often only used to mitigate variable omission bias problem in traditional investment regression or sort out/ identify financially constrained firms. Sales or cash flows are, on the other hand, often used either as ad hoc proxy for a firm financial status (Fazzari, et al., 1988; Hubbard, 1998) or interpreted as the by-product of measurement error in marginal q (Erickson et al., 2000; Gomes, 2001; and Cooper et al., 2003). Gala and Gomes

(2012) showed that firm size could become an important determinant of investment whenever Tobin's q is not a sufficient statistic even in the absence of financial market frictions. Similarly, they suggested that sales or cash flows if used as state variables in investment equation could be able to capture the shocks to productivity, demand and any variations in factor prices.

To some extent, the idea of including sales and cash flows as state variable has been slightly touched upon by some previous studies, albeit under mildly different lights; most notably are those by Gomes (2001) and Cooper and Ejarque (2003). However, the role of cash flows in these studies is still at most confined to justifying the findings based on the q type investment regression. In most cases, their contribution in the model is considered only marginal relative to that of Tobin's q.

Gala and Gomes (2012) study also stood out in comparison to previous literature in the sense that it doesn't ask for exact market value of firm's stock or debt securities. This approach help mitigate the concerns arising from potential stock market misevaluation and approximations of unavailable market values of debt securities (Blanchard et al., 1993). It is in their intention to limit any potential errors to the measurement of the firm capital stock, which Erickson and Whited (2000, 2006) believed to contain less noise. Their proposed variables are undoubtedly also subject to measurement error but believed to be at a much lesser degree than in Tobin's q.

In the context of an imperfect market, Gala and Gomez's innovative model seems also superior to any prior model in the way that it can easily accommodate for any financial frictions by adding few minor adjustments. For instance, they accounted for the deviations from M-M theorem by including in the model different measures of financial leverage as state variables. Similarly, by including lagged investment as additional state variable for the optimal investment policy, the effect of complex adjustment cost specification could be comfortably accounted for as proven in Eberly et al. (2011)

The result of Gala and Gomes' study shows that their model could be used as a new framework for many other investment studies without having to rely on the proper estimate of Tobin's q.

3. Hypotheses

In this section I propose several hypotheses in which many of them are indirectly linked or deduced from the findings of Gala and Gomes's and other related studies.

H1a: *Firm with lowered level of fixed assets is more willing to invest than the others*

H1b: *Firm with lowered human capital based is likely to spend more money on annual investment*

H2: *Firm with higher sales to capital ratio, a.k.a. firm's productivity or its ability to generate sales revenue by utilizing its assets, tends to invest more*

H3a: *Firm size and sales to capital ratio can explain a company's investment behavior much better than traditional Tobin's q*

H3b: *Tobin's q adds very little independent information for investment beyond the information already captured by firm size and sales to capital ratio variables.*

H4: *Financially constrained firms are more reluctant to make continuous investment.*

H5: *Last year's investment can have significant impact on the level of a firm this year's investment.*

4. Research Methodology

For easy comparison and interpretation, I mostly strictly followed the methodology proposed by Gala and Gomes study. However, couple of minor modifications in the use of additional proxy variables have been applied to where I believe is appropriate. These modifications shouldn't have any major effect on the final outcome yet it would probably make the result more meaningful and reliable.

4.1. Gala and Gomes' framework

Since the linear quadratic Q model contained many restrictions in its form, Gala and Gomes (2012) decided to start to build the structural framework from the general model in Abel and Eberly (1994, 1997). This model allows for asymmetric, non-convex and possibly discontinuous adjustment costs, which is strengthened with weakly concave technology that allows for decreasing returns to scale. To avoid unnecessary complications in the first stage of building this model, the authors decided to take for granted that the market is somewhat perfect. However, essential modifications will be undertaken and addressed to account for financial market imperfections in later stage of this study.

4.1.1. The general model

In theory, a firm ultimate objective would be maximizing shareholder wealth and this should be well reflected in its management's investment decision making. Based on this assumption, Gala and Gomes started with the examination of the optimal investment decision of any particular firm in the absence of any financial frictions. And for simplicity’s sake, the firm is assumed to be entirely financed by equity

For a starter, V is assigned to be the maximum current shareholder value a firm could achieve in an investment decision and D is the value of periodic distributions net of any securities issuance.

The operating cash flows or profit of any particular firm is defined as sales revenues net of operating costs which they denote as $\prod$

$$\prod\left(K_t, A_{t,} W_t\right) = \max_{N_t}\{A_t F(K_t, N_t) - W_t N_t\} \quad (1)$$

Where $Y_t = A_t F(K_t, N_t)$ represents the value of sales revenues in period t, net of the cost of any materials. These revenues are conditional on the firm's capital stock and labor input, denoted by K_t and N_t, respectively. The variable $A_t$is supposed to capture all the exogenous state of demand and productivity in which a firm operates while $W_t$controls for unit labor costs, including wages, taxes, and other employee benefits. In this particular model, $W_t$and $A_t$are allowed to vary stochastically over time which enables them to accommodate any variation to the state of the economy or industry in which the firm operates.

Any model would require certain fundamental assumptions in order to be applicable. This model is not an exception and thus Gala and Gomes have introduced two key assumptions about **Sales** and **Costs** that will be used throughout this study.

4.1.1.1. Sales assumption

The function $F : K \times N \to R_+,$ (i) is increasing and concave in both K and N; (ii) is twice continuously differentiable, (iii) satisfies $F\ (hK, hN, A) \leq hF(K, N)$ for all (K, N); and (iv) obeys the standard Inada boundary conditions.

While the first two conditions are quite the norms, the third condition (iii) set this model apart from its peers. In fact, it allows for the possibility of decreasing returns to scale while being the first to take the stand from the standard linear homogenous model. Consequently, the function $\prod$ can be easily proved to be increasing and weakly concave in K.

Based on the fact that physical capital accumulation requires capital expenditure or investment, I_t, and consumes time, Gala et al. (2012) formulize the idea of time to build under assumption that current investment spending does not affect the current of level installed capacity and become part of firm physical capital only at the end of the next period:

$$K_{t+1} = (1 - \delta)K_t + I_t\ (2)$$

While assumptions on sales play an important role in determining the success of the model, it's also necessary to take into account the adjusting costs of the stock of capital which presumably reduce operating profits. Gala and Gomes (2012) summarized this effect in the function Φ which is dependent on the amount of investment and the current stock of capital. This second major assumption about the adjustment cost is elaborated in more details as bellow.

4.1.1.2. Cost assumption

The adjustment cost functionΦ: $I \times K \to R_+$, (i) twice continuously differentiable for$I \neq I(K)$; (ii) $\Phi(I(K), K) =\ 0$; (iii)$\Phi_I \times (I - I(K)) \geq 0$; (iv)$\Phi_K \leq 0$; and (v) $\Phi_{II} \geq 0$.

The second and the third conditions are there to ensure that the adjustment costs are non-negative and minimized at the natural rate of investment I(K). The first condition, on the other hand, allows for the possibility of general non convex and discontinuous adjustment costs. There is a general equation that could satisfy all these assumptions:

$$\Phi(I,K)=\begin{cases} a^{+}+p^{+}I+\dfrac{b^{+}}{v}\left(\dfrac{I-I(K)}{K}\right)^{v} & if\ I>I(K) \\ 0 & if\ I\ =I(K) \\ a^{-}+p^{-}I+\dfrac{b^{-}}{v}\left(\dfrac{I-I(K)}{K}\right)^{v} & if\ I<I(K) \end{cases} \quad (3)$$

Where a^{+}, a^{-}, p^{+}, p^{-}, b^{+} and b^{-} are all non negative, and $v \in \{2,4,6\ldots\}$. These conditions allow for a non-convex and discontinuous fixed cost of investment when a^{+} and/ or a^{-} are positive. The linear costs of investment are discontinuous when the purchase price of capitalp^{+}, differs from the sale price p^{-}, with $p^{+}>p^{-}\geq 0$ reflecting fire sales. The function becomes asymmetric and convex when b^{+}differs from b^{-} and $v>1$, with $b^{-}>b^{+}\geq 0$ reflecting cost reversibility. The special case in which standard smooth quadratic adjustment costs occur is when $v=2,\ a^{+}=a^{-}=0, p^{+}=p^{-}>0$, and $b^{+}=\ b^{-}>0$.

4.1.2. The investment decision

With these assumptions about sales and adjustment costs in place, Gala et al. (2012) proceeded to define the sequence of optimal investment decision by the firm as the solution to the following problem:

$$V\left(K_t,A_{t,}W_{t,}\Omega_t\right)=\max_{\{I_{t+s},K_{t+s+1}\}_{s=0}^{\infty}} E_t\left[\sum_{s=0}^{\infty} M_{t,t+s}D_{t+s}\right] \ (4)$$

$$s.t.\ \Pi\left(K_{t+s},A_{t+s,}\,W_{t+s}\right)=\ D_{t+s}+\phi(I_{t+s},K_{t+s})\ (5)$$

Where $M_{t,t+s}$ is the stochastic discount factor between periods t and t+s, and Ω_t denotes the set of aggregate state variables summarizing the state of the economy. The set of aggregate state variables could include aggregate shocks to productivity, wages, capital adjustment costs, relative price of investment goods, and representative household preferences.

4.1.3. Smooth policies

In order for the value function V to be differentiable, the condition $a^{+}=a^{-}=0$ must be met. When V becomes differentiable, the first order condition could be used to solve the equation (4).

The optimal investment policy, according to Gala et al., (2012), can be then written in the following form:

$$q_t = \Phi_I(I_{t,}K_t) \ (6)$$

Where q_t is the marginal value of installed capital which follows the law of motion:

$$q_t = E_t\left[M_{t,t+1}(\Pi_K(K_{t+1}, A_{t+1}, W_{t+1}) + (1-\delta)q_{t+1} - \Phi_K(I_{t+1}, K_{t+1}))\right] \ (7)$$

4.1.4. Investment equation

In theory, the optimal investment policies would be achieved by solving the combined equations (6) and (7). However, an explicit closed form solution is not a viable option under those predetermined conditions. To overcome this problem, Gala et al. (2012) suggested a proper transformation for equation (6):

$$\frac{I_t}{K_t} = \breve{G}\ (K_t, q_t)(8)$$

In his early study, Hayashi (1982) has established his assumption about linear homogeneity for the function Π and Φ which is then widely followed by other researchers to obtain a linear investment equation from (6) under quadratic adjustment costs:

$$\frac{I_t}{K_t} = a_0 + a_1 q_t \ (9)$$

Under these conditions, they could safely assume that q_t equals the Q ratio between the market value and replacement cost of capital. This assumption enabled them to directly estimate the equation (9) from the data. However, this simple linear equation is subject to high degree of measurement errors and offer a poor fit to firm level data.

The problem is more severe under less restrictive condition since marginal q is then not directly observable. Fortunately, under the law of motion, the marginal value of installed capital can always be written in the form $q_t = q(K_t, Z_t)$ where the vector Z captures possible shocks to firm productivity, firm output demand, firm wages, and aggregate state variables.

$$Z_t = (A_t, W_t, \Omega_t)$$

The optimal rate of investment can then be estimated by the following state variable representation (Gala, et al., 2012):

$$\frac{I_t}{K_t} = G(K_t, Z_t) \ (10)$$

Where the explicit form of function G depends upon the specific functional forms of Π and Φ which are not always available. Nevertheless, the unknown function G can be directly estimated by polynomials in K and Z as long as these underlying state variables and the investment are measurable.

4.1.5. Non-smooth policies

In reality, there also exist non-convex adjustment costs, i.e. $a^{+} \neq a^{-} \neq 0$. Under this circumstance, the optimal investment policy can still be represented by the formula (10), only that it is now discontinuous. Consequently, the optimal investment policy might be approximated either with the endogenous point of discontinuity or higher order of polynomial terms to better capture the nonlinearities. In their study, Gala et al. (2012) approximated the optimal investment rate using second approach.

4.1.6. The estimation approach

Since the original simple linear model offers a poor fit to firm level data, many authors have attempted to modify this model by relaxing some assumptions about technology and costs (Lindeberg et al., 1981; Megna et al., 1993). This approach, in fact, has yielded some improved results while still being close to the basic linear model.

In their attempt to avoid the common failure in prior related studies, Gala et al. (2012) have come up with a new approach which conveniently doesn't require imposing additional conditions beyond the assumption 1 and 2. Their new method, instead, focuses on approximating the general investment equation by using a polynomial version of general function G (K, Z). The optimal investment policy then can be written under approximate form of tensor product representation as follow:

$$\frac{I}{K} \cong \sum_{i_k=0}^{n_k} \sum_{i_z=0}^{n_z} c_{i_k,i_z} k^{i_k} z^{i_z} \ (11)$$

Where z = Log (Z) and k = Log (K).

The coefficients c_{i_k,i_z} are estimated via ordinary least squares approximation. Their results can be further used to infer the underlying structural parameters of the model or impose restrictions on the nature of technology and adjustment costs.

4.1.7. Measurement issues

From Gala and Gomes' perspective the most critical concern involves the measurement of the state variables in which the exogenous state Z takes priority. Despite being unable to be directly observable, it can be estimated thanks to the theoretical restrictions imposed on the model.

To simplify matter, the authors started first with the assumption that the only sources of uncertainty are in firm technology and demand, i.e. z = Log (A). The shocks then can be directly estimated from the sales in a manner similar to the construction of Solow residuals:

$$z = y - Log\ F(K, N)(12)$$

Where y = Log (Y)

Upon obtaining the estimate of Z from the equation (12), the sales shocks z could then be fed back into the investment equation (11) to estimate the optimal investment rate. However, this approach might prompt some doubts from many other researchers at its practicalities. First of all, in order for this method to work, the functional form of F has to be specific or at least the labor and capital elasticity, α_N and α_K, have to be estimated. Secondly, a correction for the endogeneity bias while estimating z is essentially needed, especially when z is persistent. If this problem is not properly addressed there would be an endogenous correlation between capital input and current productivity which in turn make the estimate of α_K and α_N inconsistent.

Fortunately, since the focus of this study is on estimating investment equations and not in identifying the capital and labor elasticity, the aforementioned problems would be avoided by substituting z in equation (12) into the investment equation (11). The resulting equation would appear as follows:

$$\frac{I}{K} \cong \sum_{i_k=0}^{n_k} \sum_{i_y=0}^{n_y} \sum_{i_n=0}^{n_n} b_{i_k,i_y,i_n} k^{i_k} y^{i_y} n^{i_n} \quad (13)$$

As we can see the investment equation is now a direct function of three observable variables including capital, sales and labor. These variables could be easily estimated from mostly any dataset.

One notable advantage of this equation is that all independent variables are in Log form which enable the authors to scale N and Y by the size of the capital stock and then estimate the equation (13) using Log (Y/K) and Log (N/K). The purpose of this transformation is to provide a better fir for the model owing to skewness in the firm level data while also making it easier to compare the outcome with prior studies.

4.2. Regression model

In this section, I show how Gala et al. (2012) constructed their investment model under various specifications.

4.2.1. Time and firm fixed effects

As mentioned before the aggregate state variables,Ω, can be also part of the exogenous state Z. To ensure that all variations in these variables affect all firms equally, the term $b_{0,0,0}$ in equation (13) is allowed to be time specific.

Apart from the time fixed effect, each firm also has different natural rate of investment due to the variations in the depreciation rates on its assets. This heterogeneity in depreciation rates can be captured by allowing for the term $b_{0,0,0}$ in equation (13) to be firm specific.

The general regression model with these two fixed effects incorporated can thus be written as follows:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively.

Meanwhile, X denote a set of explanatory state variables, including firm size, $Log\ K$, firm's sales to capital ratio, $Log\ (\frac{Y}{K})$, firm's employment to capital ratio, $Log\ (\frac{N}{K})$, and their respective higher order terms and interaction terms.

4.2.2. Labor market shocks and role of cash flow

The equation (13) also raises another question about its practicality when the sources of uncertainty are not only from the firm technology and demand but also from firm specific wage shocks as presupposed earlier, i.e. $z \neq lnA$. Consequently, the equation (13) could actually be misspecified under this specific scenario.

A possible remedy for this pitfall is to utilize the profit maximizing equation (1). In fact, the unobserved state variable z could then be constructed under the assumption that the labor share is constant:

$$z = \pi - \theta_K k \ (15)$$

Where $\pi = log\Pi$

As we can see, z now nicely captures both the productivity, A, and wage shock, W, and θ_K is the share of capital in operating profit. The original investment equation can now be rewritten as follows:

$$\frac{I}{K} \cong \sum_{i_k=0}^{n_k} \sum_{i_\pi=0}^{n_\pi} a_{i_k, i_\pi} k^{i_k} \pi^{i_\pi} \ (16)$$

The new model could be now easily estimated using data on operating profits and stock of capital. The only downfall of this equation (13) is the assumption of a constant labor share, which involuntarily restrict the production function to Cobb Douglas. Fortunately, this assumption is pretty safe under the support of ample evidence from much empirical research (Abel, 1997, 2002 and Gala, 2011).

With cash flow being added to the original set of state variables, the regression model now has the following form:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X denote a set of explanatory state variables, including firm size, $Log\ K$, firm's cash flow to capital ratio, $Log\ (\frac{CF}{K})$, and their respective higher order terms and interaction terms.

4.2.3. Capital market imperfections and the use of leverage

In the very beginning of this study, Gala et al. (2012) have made an explicit assumption that the market is perfect and the Modigliani -Miller theorem hold. This assumption enables them to avoid unnecessary complications when constructing the investment model in its early stage.

The evident benefit of this approach is that it can easily adapt itself to more modern models when marginal q is no longer a sufficient statistics for investment by allowing for the present of additional state variables in the optimal investment policy.

In this particular case, such financial frictions as tax benefits of debt, collateral requirements and costly external financing could be accounted for by allowing for debt, B, to be the additional state variable for the optimal investment policy

$$\frac{I}{K} = G(K, B, Z)\ (20)$$

In fact, the use of leverage as an addition state variable for the optimal investment policy under the assumption of an imperfect capital market has been abundantly used in many prior studies, notably are those of Whited (1992), Bond et al. (1994), Gilchrist et al.(1999), Hennessy et al. (2007), Bustamante (2011), and Bolton et al. (2011).

The regression model with the inclusion of leverage terms as additional state variables can be seen as follows:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X denote a set of explanatory state variables, including firm size, $Log\ K$, firm's sales to capital ratio, $Log\ (\frac{Y}{K})$, firm's leverage to capital ratio, $Log\ (\frac{B}{K})$, and their respective higher order terms and interaction terms.

4.2.4. Time-to-build adjustment costs and role of lagged investment

In the previous section, I discussed about the impact of leverage on the original model and how its inclusion could account for some unobservable financial frictions. This section is reserved to address another complication caused by alternative form of adjustment costs, which is known as time to build effect.

Consistent with prior studies of Bond et al. (1994) and Eberly, et al. (2012), who used lagged investment as a proxy for adjustment cost related-effects, Gala and Gomes (2012) introduced lagged investment as an additional state variable to the optimal investment policy G. The benefit of this approach is that the model can accommodate such frictions as time to build or another complex adjustment costs. In addition, the inclusion of the lagged investment can help explain the popular serial correlation in investment expenditures and possible micro foundation for more complex adjustment costs. To avoid the endogeneity problem in dynamic panel data, the lagged investment is instrumented with prior two lags of its first difference.

Below is the regression model after lagged investment is incorporated into the original equation:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X denote a set of explanatory state variables, including lagged investment, firm size, $Log\ K$, firm's sales to capital ratio, $Log\ (\frac{Y}{K})$, firm's cash flow to capital ratio, $Log\ (\frac{CF}{K})$, Tobin Q, $Log\ Q$, and their respective higher order terms and interaction terms.

4.3. Considerations on Gala and Gomes model

There are two primary concerns with the current Gala and Gomes model. First of all, I notice that except for primary state variable like firm size, sales and employment, all other exogenous variable always enter the investment model in their natural form, instead of in the log form as it has been for core state variable. I find it is inconsistent and might be even contradict with the design of their general model (11):

$$\frac{I}{K} \cong \sum_{i_k=0}^{n_k} \sum_{i_z=0}^{n_z} c_{i_k,i_z} k^{i_k} z^{i_z}$$

Where z = log(Z) and k = log(K)

The effect of using a mix of natural and log form for a group of variables might be more detrimental than beneficial since it likely makes the results harder to interpret. Therefore I decide to use log form for all exogenous variable whether they are primary state variables or not. This is clearly shown in all of the regression models in which I always use the log form regardless of the state variable is debt, cash flow, or leverage term. Nevertheless, for easy comparison, I also run the regression in which these additional state variables enter the model in natural form as presented in Gala and Gomes model to see if the result would differ.

The second issue with Gala and Gomes model is concerned with the order of the polynomial and its usage. Empirical evidence shows that using higher order of the polynomial can often cause multicolinearity problem. In many cases the existence of multicolinearity in a model usually makes it much harder to achieve a precise estimate for each individual coefficient. However, we can easily see that higher order polynomial is quite an important component of the designed model, and thus simply taking it away is not really recommended. Fortunately, since the focus of this model is more on its overall fit while being less concerned with the significance of the individual coefficient, the existence of higher order of polynomial terms is temporarily acceptable.

Gala and Gomes claims that any order higher than second order of polynomial terms would be not statistically be significant and generally not necessary to improve the quality of the approximation. This statement is directly deduced from the result of their analysis in which different order of polynomial terms are alternatively put under significance test. Since I cannot at this moment testify the validity of their claimant it would be reasonable to first run all of the regression with only second order polynomial term included. Depending on the results, I will decide to incorporate or not higher than second order terms in my model.

5. Data Description

My dataset is mainly collected from Thomson Financial One Banker and the target time period is about 12 years, from 2000 to 2012. Since the focus of my study is on European markets, I restricted my data search to public companies that are currently listed on major European stock exchanges, namely London Stock Exchange, Frankfurt Stock Exchange, Paris Stock Exchange, Brussels Stock Exchange, Amsterdam Stock Exchange, Lisbon Stock Exchange and Helsinki Stock Exchange. Despite having relatively large stock exchanges in Europe, Spain and Italy are not included in my list due to the severe lack of data available. To make my data more comparable to the one collected by Gala and Gomes (2012), I included at first in the dataset only manufacturing firms (SIC 2000 -3999) with at least five years of available accounting data. However, I later conduct a couple of other analysis on broader cross-section firms to see if the model is still robust.

Below is the list of primary state variables that I would use in my regression model

- Investment (I) is defined as capital expenditures in property, plant and equipment.
- Firm size (K) is defined as net property, plant and equipment.
- Employment (N) is defined as reported number of employees
- Sale revenues (Y) is defined as net sales revenues
- Cash flow (CF) is defined as earnings before extraordinary items plus depreciation.
- Tobin's Q (Q) is computed by the market value of assets (book value of assets plus the market value of common stock minus the book value of common stock) divided by the book value of assets.
- Leverage (B) is calculated as debt divided by total firm's assets

To have the sense of how many actual observations I can gather from the database, I voluntarily removed all observations that have total capital, book value of assets, and sales either negative or zero. In addition, I follow Gala and Gomes in cutting at the 1st and 99th percentiles of their distributions to mitigate the influence of the outliers, which are common in accounting ratios. In the end, I manage to collect 7225 observations from the original set of 50000 observations. Out of 7225 observations there are approximately 2465 observations for the subsample that includes only manufacturing firms.

6. Analysis and findings

6.1. Examination of investment rate variation by state variable portfolios

My first analysis is focused on the level of impact each of the core state variable might have on the investment rate. The result of this analysis hopefully could give me some first insight about the relation between firm size, sales, employment and company's investment decision making.

6.1.1. Single sort state variable

The methodology used in this portfolio analysis originates from Gala and Gomes study (2012). Firms are sorted in separate decile portfolios which are rebalanced every year. In panel A, firms are sorted out according to their firm size while in panel B and C firms are categorized according to their sales to capital to ratio and employment to capital respectively. Each of the cell in panel is the average investment rate for all the firms within the same decile. To ensure this value truly reflect the average investment rate of the firms within that decile I computed both equal weighted and capital weighted average mean annual investment rate for each of these portfolios. The results of this portfolios analysis are reported in table II in appendices.

6.1.1.1. Firm size

In the panel A, we can see that investment rate seems to decrease significantly with firm size. The smallest firms which are in the first decile portfolio grow almost 4 time faster than those biggest firm in the last decile both in equal weighted and capital weighted mean calculations. This result is consistent with the finding of Gala and Gomes paper based on similar study framework. However, the magnitude in which small firms outgrow big firms is significantly different between my study and that of Gala and Gomes. While their smaller firms only manage to outgrow those bigger firms by about 70 percent, the small firms in my sample grow on average 300% faster than their peers. The difference in magnitude of growth rate might come from the difference in sample size between their study and mine. The main conclusion, however, still holds for both studies, in which smaller firms seems to be more willing to invest than bigger firms.

6.1.1.2. Sales

The whole sorting process is repeated in panel B except that this time I sort out firms according to their sales to capital ratio. The result of the analysis in panel B is reported in table 2. We can see that the relation between firm sales to capital ratio and investment rate is not as clear as the one between firm size and investment rate. While it seems that investment rate increase with sales to capital ratios under capital weighted mean calculation, the result is mixed under equal weighted average method. We can reason that the size of firm capital might have certain effect on the firm investment decision and thus capital weighted average mean might be a better way of computing firm annual average investment rate. If this reason is sound, firms with smaller sales to capital should grow faster according to my presented results, which is in Gala and Gomes study also their conclusion based on this approach.

6.1.1.3. Employment

The whole process is once again replicated in panel C in which this time I use employment to capital ratio is the main sorting criteria. The outcome of this analysis can be found in table 2 under panel C section. Unlike in other two panels, I cannot find any meaningful relation between firm investment rate and its employment to capital ratio under either equal weighted and capital weighted average way of computation. This is different from what Gala and Gomes found in their study in which they showed that investment rate seem to increase with the employment to capital rate. I can attribute the divergence between our results to the lack of sufficient data on firm's employment. In fact, I had to drop quite a handful number of observations mostly due to the lack of data on employment in this analysis. However, another possible explanation for this difference in result is that there is actually no relation between these two state variables and what Gala and Gomes found in their study is just a coincidence.

6.1.2. Double sort state variables

The framework for this analysis also comes from Gala and Gomes study of which I find it a useful and decent method to examine the variation rate of investment rate across portfolios.

In this framework, firms are double sorted in separate portfolios according to empirical distribution of the variable of interests. For instance, firms in panel A are double sorted on the empirical distribution of the sales to capital ratio conditional on firm size while firms in panel B are double sorted on the empirical distribution of the employment to capital ratio conditional on firm size. Each cell in these two panels reports the average investment rate for all the firms within the same double sorted portfolio. The result of this portfolio analysis is presented in table III.

6.1.2.1. Double sorted on firm size and sales

In panel A, we can see that firms investment rate increase steadily with the sales to capital ratio. On average, within the same firm size quintile investment rate for firm with highest sales to capital ratio is almost 2 times that of firm with lowest sales to capital ratio. This positive correlation, however, is not that obvious for the firms in the first and second firm size quintile. I notice that within these two firm size quintiles, there exist moment in which firms investment rate seem to decrease with sales to capital ratios. This disruption in the pattern can be attributed to the possibly sporadic investment behavior of smaller firms with regard to their investment decision making. Nevertheless, the evident trend is still that firms with similar size tend to increase their investment with sales to capital ratio. This result is mostly in line with Gala and Gomes study in which they show that average investment rate increase monotonically with the sales to capital ratios.

6.1.2.2. Double sorted on firm size and employment

Panel B report the result of similar analysis with the panel A except that employment to capital ratio is used in place of sales to capital ratio as one of sorting out conditions. As we can see, there is no clear relation between firm investment rate and employment to capital ratio within each firm size quintile. Except for firm size quintile 2 in which we see a steady increase in investment rate along with the employment to capital ratio, the result is rather mixed for other firm size quintile. In most cases, however, we can still see that within a firm size quintile firm investment rate with highest employment to capital ratio is still larger than that of firm with lowest employment to capital ratio albeit relatively small. Thus I cannot make any conclusive implication with regard to relation between firm investment rate and employment to capital ratio in this case. This outcome is somewhat contradict with what Gala and Gomes found in their study in which investment rate of firms with similar size seem to increase with sales to capital.

One the one hand, we might attribute the divergence in the result to the lack of sufficient data on firm employment. On the other hand, the discovery of positive correlation between firm investment rate and sales to capital ratio in Gala and Gomes study might be only by pure chance.

Overall, the result from single and double sorted portfolio analysis help lend support to my hypotheses 1a and 2 in which firms with higher capital concentrated and productivity is more willing to invest than the others. The outcome, however, is not significant to reject or lend support to hypothesis 1b in which firm with lowered human capital based tend to invest more. Another implication could be deduced from the results of this portfolio analysis is that firm size, sales and employment seem to be able to capture a significant variation in firm investment rates, although the effect might be more pronounced in case of firm size and sales.

6.2. Investment Regression

Encouraged by the results of previous portfolio analysis, I proceed to test the relation between firm investment rate and those state variables in a formal regression framework. In this specific framework, investment rate play the role of endogenous variable which is dependent on other exogenous variable like firm size, sales and employment. Apart from these core state variables, I plan to add couple of additional variables like cash flow, leverage or lagged investment at some points to account for certain effects or circumstances that these core state variable fails to capture. All of the investment regressions in this section will mostly derive from the equation 13:

$$\frac{I}{K} \cong \sum_{i_k=0}^{n_k} \sum_{i_y=0}^{n_y} \sum_{i_n=0}^{n_n} b_{i_k,i_y,i_n} k^{i_k} y^{i_y} n^{i_n} \quad (13)$$

In addition, to ensure that the effect of cross sectional variation in the firm depreciation rate and other unobserved aggregate variation are all well captured in the model, I decide to always include in my regression model time and firm fixed effects.

6.2.1. Investment Polynomials

In a polynomial regression, it is crucially important to know not only what state variables should be included in the model but also what polynomial order of these state variables should be taken into account. To ensure that everything would be more or less covered, I conduct the investment polynomial regression for various specifications.

Table IV reports the result of my first investment polynomial regression under several circumstances. The first 5 columns present the outcome of the regression with only sales to capital ratio and firm size as state variables. Second, third polynomial order and interaction term are subsequently added to the equation in column 2, 3, 4 and 5. As we can see the coefficient of firm size and sales to capital ratio in (1) are both statistically significant with firm size coefficient being highly negative. This is consistent with the findings of Gala and Julio (2011) study in which firm size is found to be negatively related to investment rate. The positivity of coefficient of sales to capital ratio, albeit not as strongly, also lends certain support to positive relation between productivity shocks (represented by sales to capital ratio) and investment predicted by neoclassical investment theory. My hypothesis 1a and 2 are, once again, supported in the light of this result.

I proceed to report the result of augmented model with higher order terms. The result shows that adding second order terms of these state variables (2) help increase the fitness of the model significantly by almost 40% while keeping both first and second order terms coefficient statistically significant. However, including the interaction term in the model (3) only helps increase the quality of model by a margin of 0.5%. This preliminary result is consistent with Gala and Gomes study in which they were able to prove that second order terms help increase the overall fit for investment substantially while interaction terms contribute very little, if anything, to the model.

According to Gala and Gomes study, any order higher than second order term would be not statistically significant and generally unnecessary to improve the quality of the approximation. This, however, is not the case in my study. Result from the column 4 shows that third order terms not only enter the model significantly but also help improve the quality of the model to a large extent. More precisely, the inclusion of the third order term helps bring the model within transformation R2 from 5.8% to 7.8%, up by almost 60%. Adding interaction term after already including third order terms in the model (5) once again doesn't help much in improving the quality of the model. I proceed to test the model with some higher order terms of these state variables and notice that any order higher than third order terms doesn't add much quality value to the model and decide to omit them for brevity.

The last five columns introduce my third core state variable, namely employment to capital ratio, to the model. As we can see, adding employment to capital ratio to the model only improve the overall fitness of the model slightly, from 3.64% to 3.77% despite the fact that all three core state variables still enter the model significantly. There is, however, a substantial increase in the model fitness when second term is introduced to the model (7). The within transformation R2 increases almost 3 times, from 3.77% to 10.74% with mere inclusion of second order terms. In their study, Gala and Gomes stop after introducing second order term yet my prior regression results with first two state variables suggest that not only second order but also third order terms can have a significant impact on the model quality. In fact, with the presence of third order term the overall fitness of the model once again is improved dramatically, from 10.47% to 16.66%. In addition, all of three state variables and their polynomial orders are statistically significant, albeit some are more significant than others. Similar to the previous case when I use only firm size and sales to capital as state variables, the addition of interaction terms to the model with all three state variables (10) can only increase the overall fitness of the model by a margin of 1%. However, the inclusion of these interaction terms seems to have a negative effect on the significance of the coefficient of all core state variables, especially sales to capital ratio whose coefficient is no long statistically significant. This is not likely a big issue since Gala and Gomes objective as well as mine in establishing this regression model is to focus more on the model's overall fit improvement while less concerned with the statistical significance of state variable coefficients.

6.2.2. Comparison with standard q-based regression

With the result from the previous regression analysis, I can temporarily conclude that representatives of firm size, sales and employment variables can capture substantial variation in the firm investment rate which is in support of my hypothesis 3a. My next objective is to show

how the regression model with these three as core state variables is superior compare to standard q-based investment regression.

In order to do that I first have to decide what measure of Tobin's q used in coming regressions is the most appropriate. Many prior q-studies show that marginal q, not average q, is the better and true measure of Tobin's albeit marginal q is often unobservable. Fortunately, Hayashi (1982), in his famous neoclassical investment theory, proved that average q could be equal to marginal q if the firm is a price taker and the production and installation functions are linear homogenous. For easy comparison and the sake of simplicity, I presume that these two conditions are met and use average q as the representative measure of Tobin's in these regressions.

The comparison result is reported in table V and VI and is conducted using both fixed effect and first difference estimator.

6.2.2.1. Fixed effect estimators

The result of fixed effect estimators is presented in table V. In this table I report the fixed effects (within transformation) estimates for various specifications of the investment regression. Time and firm fixed effects are two main fixed effects that always included in the model in all circumstances. In the first two columns, I run the test with the traditional standard q- based investment regression. The result shows that Tobin's q's coefficient is not statistically significant albeit positive as predicted by the neoclassical investment theory. In addition, Tobin's q alone can only help explain less than 1% of the within variation in the investment rate. While I can attribute the lack of significance in the Tobin's q coefficient to the lack of sufficiently large number of observations, its relatively marginal contribution to help explain the variation in investment rate is consistent with my hypothesis and the result of Gala and Gomes's study. Even when higher order terms in q is added to the model to account for potential nonlinearities in the relationship between investment and Tobin's q, the result is still more or less the same. The Tobin's q coefficient is still statistically insignificant even though the inclusion of the higher order of q terms help improve the quality of the model slightly, from 0.01% to 0.03%.

In column 3 and 4, I reported the result of the regression with representative of firm size and sales and their higher polynomial order as the main state variables. As we can see, with firm size and sales as state variables, the fitness of the model (3) is improved drastically to 8.41%. The inclusion of Tobin's q later to the regression model (4) doesn't help much in improving the model overall fit. In fact, the within transformation R2 is almost as the same as before Tobin's q is added to the model with firm size and sales being core state variables. This result is pretty in line with that of Gala and Gomes previous study and also in support of my hypothesis 3b in which Tobin's q add very little independent information to the model beyond what has already provided by the three core state variables.

The next two columns 5 and 6 show the effect of adding interaction terms and higher order term of Tobin's q. While the interaction enter the model (5) significantly and help improve the quality of the model substantially by almost 40%, from 8.41% to 11.88%, the inclusion of higher order term of q later in the model (6) have only negligible impact on model explanatory power. This result further underlines the Tobin's q insignificant contribution to improve the overall fit of the model.

Seeing that adding Tobin Q would only result in marginal improvement in the model quality, it would be interesting to see if adding higher then second polynomial order of core state variable to the model could do it any better. The result from the last three columns show that inclusion of third order polynomial of state variable help improve the overall fit of model moderately witnessed by the increase of within transformation R2 from 18.54% to 19.3%. Nevertheless, higher order terms of firm size and sales representative state variables still make a much more significant contribution to the model than what Tobin's q and its higher order terms combined.

6.2.2.2. First difference estimators

In table VI I report the first difference estimate for all investment regression presented in table 5. The main purpose of using the first difference estimator is to mitigate concerns about the omitted variables and possible serially correlated disturbance terms in empirical regression. The results are more or less the same to that of fixed effects estimators with some minor differences. In column (1), we can see that Tobin's not only having only negligible impact of model explanatory power but also enter model insignificantly. Adding higher order term of q doesn't help much in improving model quality while bringing down the statistical significance level of q.

Similarly, we can also see that firm size and sales to capital ratio still manage to enter the model significantly (3) under first difference estimator approach. The overall fit of the model is also improved dramatically, from 0.01% to 6.4% albeit not as much as in the case of fixed effect estimators. With representative of firm size and sales to capital ratio acting as main state variable, the inclusion of Tobin's q and its higher order terms in (5) and (6) has very little impact on the improvement of the model quality.

The result from the last three columns once again shows that adding third order polynomial of state variables does have positive effect on model explanatory power. The effect, however, is rather weak compared to the one in fixed estimator. As shown in column (8), the within transformation R2 only increase by a margin of roughly 0.3%, from 6.7% to 7% with the addition of third order terms of state variables. Adding higher order or Q term later in (9) virtually make no changes in adjusted R2.

In general, the results from the first difference estimator are quite similar compare to that of fixed effect estimator. In most cases, the effects, however, are all weakened to some extent. The weakened effect might be attributed to the use of first difference estimator approach to mitigate the negative impact of omitted variables. Despite all that, the main implication derived from the results of first difference estimators is still more or less the same from the one in fixed effect estimators. The first is that adding Q and its higher order terms to the model that has already had representative of firm size and sales to capital ratio as its core state variables has very little impact in improving model quality. Secondly, Tobin Q and its higher order terms can account for very little variation in investment rate. Finally, unlike in Gala and Gomes study, third order term of core state variables can still make quite decent contribution to the improvement of the model overall fit. In fact, the positive effects it brings to the model are more significant than Tobin Q and its higher order terms all combined. Out of these three implications, the first one is the most important since it lends strong support to my hypothesis 3b.

6.2.3. Impact of cash flow, leverage and lagged investment on investment model

6.2.3.1. Cash flow

As I already mentioned in the research framework section, the use of employment data comes with 2 undesired consequences. The first and foremost is the lack of sufficient amount of data available on any firm employment. In fact, I had to cut out a large part of my sample's observations due to the lack of employment data. The second one is the effect of firm specific wage shock of which Gala and Gomes presume vector Z could successfully capture most of it. If this effect, however, is too important for Z alone to contain it, the equation (13) might be misspecified. One possible remedy for this particular case is introducing the cash flow state variable to the model.

There exists quite a few ways to define a cash flow measurement, some more or less have been frequently used in other cash flow related studies. In this specific study, I decide to use three following alternative measure of cash flow for my regression model. The first one is computed by summing up earnings before extraordinary items and depreciations. For the second measure of cash flow, I subtract from the fund from operation non-operating income and plus interest and related expenses. The last measure of cash flow is conducted by simply adding depreciation expenses to operating income. These three measures of cash flow are used mainly because of their relatively easy way of construction and relevant data availability.

The results of investment regression estimation under various cash flow specifications are reported in table VII. Column 1-4 presented the result of my investment approximation with first measure of cash flow being used while in column 5-8 and 9-12 second and third measure of cash flow are respectively used.

As we can see from (2), adding cash flow state variable to the investment model with firm size being the only state variable help improve the overall fit of the model significantly, from 5.23% to 15.51%. In addition, the coefficient of cash flow variable is positive and statistically significant at 5% significance level. I proceed to test if adding higher order term of cash flow variable would have any significant effect on the model. The results in column (3) show that adding second and third order term of cash flow variable does help improve the model quality tremendously. It was proven by the substantial increase in within transformation R2 from 15.51% to 53.77%. Another positive effect from the inclusion of higher order terms of cash flow state variable is the increased significance of all state variables and their higher order terms. The presence of interaction terms in the model later on in (4) has virtually no impact on improving model overall fit if not vice versa. This result is consistent with the finding of Gala and Gomes' prior study. It also underlies the importance of cash flow variable in capturing firm specific wage shock effect as well as its positive contribution to the improvement of model quality. In other words, cash flow state variable can help capture a substantial amount of variation in firm investment rate.

Similar results are achieved when third measure of cash flow (9-12) is being used albeit on a weaker degree. Adding cash flow state variable to the model helps increase its overall fitness significantly by 38%, from 5.04 % to 6.96 %. The inclusions of second and third order terms of cash flow state variables later, however, only help improve model explanatory power moderately by 7%, from 6.96% to 7.45%. Interaction term once again has very negligible impact, if any, on the model overall fitness. The outcome of the second cash flow measure regression, nevertheless, continues to reinforce what I conclude about the role of cash flow in previous paragraph.

The problem, however, appears when second measure of cash flow (5-8) is being used. In this specific case, adding cash flow state variable to the model with firm size as only state variable, instead of improving model quality as anticipated, only bring down the model overall fitness almost 8 times, from 23.68% to 3.28%. This result seems to be totally in conflict with previous outcome from the investment regression in which other two measures of cash flow are used. I attribute the divergence in these results to the differences in constructing cash flow measures. While the first and third measures of cash flow are quite standard and closely related, the second measure of cash flow is less conventional and totally different from the other two. I personally prefer the use of the first and third measure of cash flow since they are more standard and yield more consistent results. Nonetheless, it would be interesting to see what other forms of cash flow measure besides these 3 could bring to the model.

6.2.3.2. Leverage

I have already touched upon the assumption of a perfect market in research framework section. The main purpose of this assumption is to alleviate the difficulty in building the model structure by constructing it in a more simplified environment. This is, however, not a case in real life when financial frictions always exist under various forms. Fortunately, Gala and Gomes's investment model is flexible enough to allow for the presence of additional state variables that hopefully could capture the large part of financial market imperfection effects. In most cases, debt is often chosen as one of the most suitable state variable that can account for many financial frictions such tax benefits of debt, collateral requirements and costly external financing. For an easy result comparison with prior literature, I decide to use debt as one of my main state variables to capture those external effects.

Similar to cash flow state variable, there are also several ways to construct a measure of debt. In this specific study, I introduce 2 most common measures of a firm debt. The first measure of debt is conducted by totaling a firms' short term and long term debts. For the second measure, I subtract the cash and short term investment from the total debt. The leverage ratio used in the regression model is then calculated by simply dividing debt by the total firm assets.

Table VIII reports the result of investment regression estimation under various leverage ratio specifications. Column 1-5 presented the result of my investment approximation with first measure of debt ratio while the second measure of leverage ratio is used in the remaining columns.

Result from column 2 show that adding debt ratio variable to the model only help increase the model explanatory power by almost 20%, from 15.56% to 18.29%. We can also see that debt ratio enters the model significantly at least at 5% significance level. Its negative sign show that debt ratio is negatively correlated with investment rate which is supporting my fourth hypothesis and in line with the result of many other studies. In previous section, we have also discovered the importance of higher order term of cash flow state variable if included in the model. Therefore I proceed to test the model with second and third order term of debt ratio variable.

The result show that including higher order terms of leverage ratio variable contribute significantly to the improvement of model overall fit, from 18.29% to 23.87%. Adding interaction terms later on to the model only helps increase the model quality a bit further by a margin of 2%, from 23.87% to 25.14%. Interestingly, the result from column 4, however, also indicate that adding interaction terms to the model could have nearly the same positive effect as adding higher order terms of debt ratio variables to the model. The implication then is that if one of these two has already appeared in the model, the inclusion of the latter one will only make very small improvement on the model explanatory power.

In contrast with the result where the first measure of leverage terms is used, adding second measure of debt ratio variable to the model only undermine the model's overall fit. In fact, we can clearly see that the within transformation R2 is brought down by almost 33% with single inclusion of debt term, from 15.56% to 10.24%. However, the coefficient of debt term is still negative as expected albeit not statistically significant as in the first case.

In a related study, Gala and Gomes (2012) also concluded that there is indeed some interaction between financing and investment decision of the firm on the ground that all of their leverage terms are generally statistically significant. Nevertheless, the amount of variation in investment rate that their leverage term can capture is limited to a meager portion of only 3%. They suggest that the importance of leverage term could be more heightened if used to address some more specific subset of firms or in different formulations of the structural model. Interestingly, they never mention if the inclusion of these leverage terms could help improve the current model overall fit.

My result is, to some extent, quite similar to that of Gala and Gomes study in which the debt terms enter the model mostly significantly with an expected negative coefficient. Despite the fact that using different measure of leverage terms yield different results in terms of improving model quality, it is still premature to make any definite conclusion about the role of leverage terms in this aspect. However, the divergent results can be somewhat attributed to currently used structural form of the model and tested sample of exclusively manufacturing firms as pointed out earlier by Gala and Gomes.

6.2.3.3. Lagged investment

In the research framework section I have shown that under certain circumstances the general optimal investment rate equation (10) might have to resort to a more complex form.

$$\frac{I_t}{K_t} = G(K_t, Z_t)$$

These circumstances often occur when the adjustments costs take on the characteristic of time to build and non-smooth form. On many occasions when this is the case, the time to build, non-smooth adjustment costs and other labor market distortions can have a significant impact on determining the changes in investment rate. Fortunately, there are several ways to remedy for such frictions and lagged investment is proved to be able to well capture the effect of time to build and other more complex adjustment cost specifications (Eberly et al., 2012).

Table 9 reports the result of using lagged investment as the additional state variable under various cash flow specifications. Column 1-4 presented the result of my investment approximation with first measure of cash flow being used while in column 5-8 and 9-12 second and third measure of cash flow are respectively used. In column 1, 4 and 7, I report the result of my investment approximation with lagged investment, Tobin's q and cash flow as main state variables. These results are used to compare with those presented in prior paper (Eberly et al., 2011, Gala et al., 2012)

The result from column 1, 5 and 9 shows that lagged investment enters the model significantly just as it did in other studies. However, this is only the case when model contain only cash flow and Tobin's Q as core state variables. The adding of lagged investment term to the model with firm size and sales to capital ratios as state variable doesn't seem to have that kind of positive effects. On the contrary, the inclusion of lagged investment even depreciates the model explanatory power, as seen from the decreased adjusted R2 from 5.49% to 1.48%. In addition, the coefficient of lagged investment term is no longer statistically significant and the overall fit of the model with firm size, sales to capital ratio and lagged investment as state variables is also much inferior to that of the model with cash flow, Tobin's q and lagged investment as state variables. This outcome is totally contradict with the result of Gala and Gomes study in which they prove that the lagged investment not only enter the model significantly but also help improve the model quality overall.

I proceed to add back cash flow, Tobin's q to the model to see if they can bring any positive effect to the current model. The result in column 4 show that with the presence of these terms, lagged investment coefficient is once again strongly statistically significant. Moreover, the overall fit of the model is also improved dramatically, from a meager 1.48% to 33.62%. The outcome of this regression also means that by simply adding firm size and sales to capital ratio variable to the model in column 1 we can improve the model overall fit by almost 43% from 22.97% to 33.62%. I can temporarily conclude that lagged investment has very little effect on helping explain the variation in investment while state variables like firm size and sales to capital ratio continue to prove their significant contribution to the improvement of the model quality. In addition, the mixed result in the statistical significance of lagged investment's coefficient in q based model and my model makes it quite difficult to conclude about the condition of my fifth hypothesis.

Since this result might be the consequence of the way that cash flow variable is constructed, I decide to run the same tests with the other two measures of cash flow. The outcome from the regression with these two other cash flow measures further reinforce what I stated earlier about the relation between lagged investments, cash flow, Tobin's q and these other two state variables (firms size and sales to capital ratio).

6.2.4. Alternative panel

Gala and Gomes predict that capital intensive manufacturing firms form probably the most reliable panel for this study. It, however, would be interesting to see whether other type of sample can also fit that well into the model. For this purpose, I attempt to test Gala and Gomes model using a new sample form which consists of not only manufacturing firms but also those from other main industries. If the results turn out well, Gala and Gomes model have the potential to be applied in a much broader scope study.

Table X reports the result of this alternative analysis. For easy comparison and computation, I only present the result of the original polynomial investment regression using the new sample. The result of this analysis is thus mainly comparable to the one reported in table 4.

In contrast with findings of Gala and Gomes study, adding non-manufacturing firms to the sample does decrease the statistical significance of the coefficient estimate and overall fitness of the model. In all cases, the within transformation R2 in the initial sample is more than 20 times larger than the one in extended samples. In addition, all three core state variables like firm size, sales and employment are not even statistically significant under many circumstances. In general, this outcome undermines the benefits and possibility of using Gala and Gomes model for other firm portfolios.

6.3. Variance decomposition

Previous to this section I have introduced two alternative approaches that can be used to analyze the effects of firm size, sales and employment on variation in investment rate. The first one is sorted portfolio analysis and the second is investment approximation. In this section I'm going to present another way of analyzing these effects. The method is involved using covariance analysis (ANCOVA) which has been successfully used in the study of Lemmon and Robert (2008) as well as Gala and Gomes (2012). The result from ANCOVA analysis can often be used to assess the relative importance of various state variables in capturing investment variation.

In table XI, I report the result of my ANCOVA analysis under various specifications. Panel A provides estimate of the fixed effects, firm size, sales and Tobin's q based on fixed effect estimators while in panel B these estimates are based on first difference estimator. Panel C is an extended version of Panel A in which it provide also the estimate of additional variables such as cash flow, leverage and lagged investment besides those already mentioned in panel A.

Each cell of every panel contains a number corresponding to a fraction of the total type III partial sum of squares for a particular model. The partial sum of square of each effect is normalized by the aggregate partial sum of squares across all effects in the model. Consequently, each value in the panel will represent the fraction of the model sum of squares attributable to a particular effect.

As we can see from the panel A, the fixed effects capture less than 1% of the total variation in the investment rate of which only 25% can be attributed to firm fixed effects. This result is not so in line with Gala and Gomes study in which they found their fixed effects manage to capture a substantial amount of variation in the investment rate. In addition, since the firm fixed effect capture the cross sectional variation in the depreciation rate, it is anticipated to account for a large part in this variation. Our results, however, prove it otherwise. In fact, the year fixed effects, which account for unobserved aggregate variation, is the one that is able to account for remaining 75% out of 1% total variation in the investment rate.

Adding Tobin q to the model with time and firm fixed effects specifications only help improve the model adjusted R2 slightly from 0.18% to 0.29%. Of which only 16% of the total explained sum of square could be attributed to Tobin's q. Firm and time fixed effects are still the dominant effects that capture the most variations in the investment rate.

The table is completely turned when firm size and sale state variable are introduced to the investment model. Their presence alone help increase the model adjusted R2 dramatically, up to

14.8% from a meager amount of 0.29%. The importance of firm size and sales state variable to the model is even more evident when we look at their contribution in terms of total explained sum of square. In fact, 99% out of 14.8% total variation in the investment rate can be attributed to firm size and sales state variable alone, leaving the remaining of less than 1% to the firm and year effects.

The inclusion of Tobin's q to the model having firm size and sales as two main state variable later only help increase the model adjusted R2 moderately from 14.9% to 15.69%. Even in this circumstance, firm size and sales still account for more than 98% of the total explained sum of square in the model while Tobin's q can only capture 1.6% out of 15.69% total variation in investment rate. Similar to Tobin's q, with firm size and sales as core state variables, firm and year fixed effects have virtually no impact on the variation in investment rate.

The result from panel A analysis once again underline the importance of these state variables in the model. It is proven by their significant contribution in determining the variation in investment rate. In addition, the outcome also help show that Tobin Q add very little independent information beyond what already captured by firm size and sales state variables to the model which is the main statement of my hypothesis 3b..

I now proceed to examine the results from panel B analysis. As we can see, the result, in most parts, is quite similar to that of panel A analysis. However, the dominating effects are weaker and the differences are much less obvious. In any cases, firm size and sales as state variables still play a very important role in the model. With their presence, the adjusted R2 of the model increase substantially, from a fraction of 0.14% to 4.23%, of which, 88% can be attributed to sales and firm size variables alone. The inclusion of Tobin's q in the model later once again only help improve model adjusted R2 marginally from 4.23% to 4.49%. Nevertheless, Tobin's q is now able to account up to 15.3% out of total explained sum of square albeit still significantly smaller than that of 76% of the core state variables. Similar to Tobin's q, fixed effects now also have certain impact on the variation in investment rate as they manage to capture more than 8% of total explained sum of square.

In general, the results from panel B analysis help reinforce what I state earlier about the importance of these state variables as well as their working relation to Tobin's q.

In panel C, the examination of these effects is extended to other variables such as cash flow, net leverage and lagged investment. The result from panel C analysis shows that sales and firm size are still very important factors in determining the variation in investment rate. They again manage to capture up to 97% of the total explained sum of square alone. Adding Tobin's q doesn't help much in improving the model overall fit. In addition, it can only account for less than 5% out of 10.7% total variation in the investment rate. Now I analyze the effects of adding other variables, instead of Tobin's q, such lagged investment, cash flow and net leverage to the model.

As we can see, adding cash flow to the model helps improve model adjusted R2 dramatically. Compared to model with which Tobin's q is a state variable, the adjusted R2 increases more than two folds, from 10.7% to 23.54%, of which 99% can be attributed to cash flow and firm size variables. This result is quite consistent with the finding of Gala and Gomes study in which they found cash flow and size variable can capture a large part of variation in investment rate.

Unfortunately, adding net leverage doesn't have that kind of positive effect on the model. In fact, the inclusion of net leverage to the model yields quite similar results to the one with which the Tobin's q is added. The result from panel C shows that the adjusted R2 of the model with Tobin's q and net leverage as state variables are 10.7% and 10.86% respectively. However, while Tobin's q still manage to capture 4.4% of total explained sum of square, net leverage term has virtually no say in explaining the variation in investment rate.

I now examine the adding effect of last variable which is lagged investment. At the first glance, the inclusion of lagged investment term to the model does help improve the model explanatory power substantially. It is witnessed by a significant increase in adjusted R2 from 10.7% as in Tobin's q based model to 14.68% as in lagged investment based model. However, in contrast with the negligible impact that Tobin's q has on the model, the lagged investment term manage to capture quite a significant amount of total explained sum of square in the model, exceeding even that of sales and size variable. The result from the column 6 show that lagged investment account for more than 74% of total explained sum of square which is three times of the amount that firm size and sales account for in the model. Interestingly, it is the opposite of what Gala and Gomes found in their related study. There exist several possible explanations to the divergence in our results. One of which concerns the way lagged investment term is constructed in the model.

Depending on how closely we follow their approach to construct the lagged investment term, the result might vary to some extent.

7. Conclusions

This thesis is an extension of Gala and Gomes study on European market. Despite the similarity in scope, the results of this paper provide addition empirical evidence to the misuse of Tobin's q in prior investment study and lend support to Gala and Gomes newly designed model. By dropping Tobin Q and instead directly approximating the more easily measurable state variables like firm size and sales, their model proves to be far superior to its peers in helping explain the investment behaviors of firms and corporations in manufacturing sector. The results of my analysis, in most parts, lend decent support to the validation of Gala and Gomes model. It shows that firm size and sales to capital ratio can indeed explain the firm investment behavior much better than traditional Tobin's q. It also proves that Tobin's q only add very little independent information beyond what already captured by firm size and sales to capital ratio variables. These results are consistent with the outcome of Gala and Gomes study (2012) and is the main base supporting their statement about the superiority of their model. Despite the seemingly superiority to q based model in explaining investment behaviors, the model doesn't seem to be flexible enough to accommodate for external factors like financial frictions or time to build effects in adjustment cost as promoted in Gala and Gomes (2012). In fact, my results show that the leverage terms as a proxy for financial frictions and lagged investment as a proxy for time to build effects in adjustment costs help very little, if any, in improving the model's explanatory power and capturing the variation in investment rate. While I cannot give a definite conclusion about the quality of their model, this outcome, to some extent, undermine its credibility and raise some doubt its ability to capture those external effects.

While the first part of my study is focused on the validation of Gala et al. (2012) model, the second part investigates the result of some prominent phenomena. The result of my portfolio analysis show that heavy capital concentrated firm is likely to invest less while highly productive firm tends to invest more. The negativity of leverage terms coefficient in one of my regression further indicate that financial constraint firm is more reluctant to make continuous investment. These results lend strong support to my H1a, H2, H3 hypotheses. There is, however, no concrete evidence that can back up the validity of H1b and H5 hypotheses since the results of my analysis with respect to these subjects are mixed or somewhat unclear.

Gala and Gomes claimed that their model would still be robust even if firms outside manufacturing sector are included in the model. The estimate result of my alternative panel analysis, however, proved it otherwise. It would be interesting to see whether the result would be different if we test the model with another set of sample that includes firms from only certain specific industries. The result of my study also shows that Gala and Gomes model might still need to be worked on before it can be used as a new framework model for assessing firm's investment behaviors. Their model seems to perform well in the perfect world where there is no tax, no financial frictions and/or no time to build effects in adjustment cost. However, once those external factors are present, the model appears to be weak in capturing those effects. If this problem would be properly addressed, Gala and Gomes model might just become the most efficient investment model just as it is designed for. As for now, I leave the work of modifying this model and testing it with other firm sample for future studies.

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Appendices

TABLE I: Descriptive Statistics

The table reports summary statistics for a set of state variables from Thomson One Banker over the period 2000-2012. Investment rate, I/K, is defined as capital expenditures in property, plant and equipment scaled by the beginning of year capital stock. The capital stock, K, is defined as net property, plant and equipment. Firm size, Log K, is the natural logarithm of the beginning of year capital stock. The sales to capital ratio, Log (Y/K), is computed as the natural logarithm of end of year sales scales by the beginning of year capital stock. The employment to capital ratio, Log (N/K), is defined as the natural logarithm of the number of employees scaled by the capital stock. The cash flow to capital ratio, Log (CF/K), is computed as the natural logarithm of the sum of earnings and depreciation scales by firm's capital stock. Tobin's Q is defined as the natural logarithm of the market value of assets scaled by the book value of assets.

	Obs	Mean	Std.Dev.	25^{th}	50^{th}	75th
I/K	1824	0.290	1.330	0.102	0.164	0.269
Log (Y/K)	1824	-1.819	0.902	-2.284	-1.805	-1.314
Log K	4406	16.699	3.137	14.570	16.781	18.855
Log (N/K)	1824	-11.083	3.184	-12.947	-10.638	-9.206
Log (CF/K)	1459	-0.078	1.252	-0.753	-0.187	0.514
Log Q	1824	0.278	0.584	-0.071	0.175	0.493

TABLE II: Single Sort State Variable Portfolios

Table 2 reports mean investment rate across Firm Size (Panel A), Sales to Capital Ratio (Panel B), and Employment to Capital Ratio (Panel C) deciles. Portfolios are formed each year by allocating firms into size, sales to capital ratio, and employment to capital ratio deciles, respectively. Both methods, equal and capital weighted averages of firm investment rates, are reported in this table.

	Panel A: Firm Size (K)									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
EW Mean (I/K)	0.648	0.623	0.477	0.427	0.367	0.249	0.348	0.216	0.171	0.175
CW Mean (I/K)	0.444	0.573	0.456	0.402	0.314	0.225	0.227	0.207	0.165	0.158

	Panel B: Sales to Capital Ratio (Y/K)									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
EW Mean (I/K)	0.179	0.426	0.679	0.263	0.322	0.480	0.481	0.436	0.570	0.723
CW Mean (I/K)	0.184	0.312	0.581	0.269	0.330	0.540	0.463	0.465	0.566	0.508

	Panel C: Employment to Capital Ratio (N/K)									
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
EW Mean (I/K)	0.195	0.360	0.298	0.260	0.386	0.388	0.360	0.664	0.800	0.429
CW Mean (I/K)	0.229	0.539	0.381	0.275	0.410	0.340	0.345	0.632	0.744	0.320

TABLE III: Double Sort State Variable Portfolios

This table reports equal weighted average in investment rates for portfolios of which one is conditional on firm size and sales to capital ratio and the other one conditional on firm size and employment to capital ratio.

	Panel A Sales to Capital Ratio (Y/K)				
Firm Size (K)	1	2	3	4	5
1	0.431	0.823	0.655	2.870	2.901
2	0.278	0.351	0.458	0.375	0.614
3	0.210	0.192	0.239	0.308	0.328
4	0.150	0.149	0.164	0.203	0.330
5	0.074	0.159	0.160	0.174	0.218

	Panel B Employment to Capital Ratio (NK)				
Firm Size (K)	1	2	3	4	5
1	1.388	2.159	2.445	0.671	1.596
2	0.313	0.420	0.482	0.351	0.507
3	0.248	0.260	0.220	0.235	0.313
4	0.183	0.190	0.212	0.193	0.219
5	0.144	0.153	0.162	0.167	0.159

<u>TABLE IV</u>: Investment Polynomials

The table reports estimates from the following investment regression:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X comprises a set of explanatory state variables, of which, $Log\ K$ represents the firm size, $Log\ (\frac{Y}{K})$ is the firm's sales to capital ratio, and $Log\ (\frac{N}{K})$ is the firm's employment to capital ratio. Higher order terms and interaction terms of these state variables are also included in X under various specifications. Asterisks indicate statistically significance at the 1% (***), 5% (**) and 10% (*). t statistics from standard errors clustered by firm are in parentheses. The sample period is from 20000-2012 including only manufacturing firms.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log (Y/K)	-0.105	-0.270	0.362	-0.567	-1.104	-0.118	-0.231	0.525	-0.380	-0.497
	(-1.27)	(-2.73)***	(0.78)	(-4.99)***	(-1.95)**	(-1.41)	(-2.38)**	(1.15)	(-3.42)***	(-0.90)
Log K	-0.559	-2.547	-2.066	-0.316	-1.150	-0.439	0.556	1.000	6.167	4.815
	(-5.85)***	(-4.80)***	(-3.26)***	(-0.14)	(-0.49)	(-3.28)***	(0.86)	(1.20)	(2.82)***	(1.99)**
Log (N/K)						0.141	2.642	2.737	5.517	4.779
						(1.28)	(7.97)***	(4.61)***	(10.86)***	(7.01)***
(Log (Y/K))^2		0.034	0.017	-0.059	-0.055		0.042	0.016	-0.038	-0.056
		(1.8)**	(0.76)	(-2.25)**	(-2.06)**		(2.25)**	(0.72)	(-1.51)*	(-2.13)**
(Log (K))^2		0.069	0.054	-0.077	-0.032		-0.011	-0.066	-0.374	-0.319
		(3.92)***	(2.62)***	(-0.51)	(-0.21)		(-0.56)	(-1.70)**	(-2.53)***	(-2.01)**
(Log (N/K))^2							0.103	0.038	0.413	0.350
							(8.03)***	(1.30)	(9.28)***	(5.94)***
(Log (Y/K))^3				0.023	0.025				0.020	0.023
				(5.17)***	(5.05)***				(4.7)***	(4.74)***
(Log (K))^3				0.003	0.002				0.007	0.006
				(0.85)	(0.61)				(2.23)**	(1.82)**
(Log (N/K))^3									0.010	0.009
									(7.29)***	(6.22)***
Log (Y/K)*Log (K)			-0.045		0.036			0.029		0.086
			(-1.39)		(0.97)			(0.75)		(1.88)**
Log(Y/K)*Log(N/K)								0.121		0.118
								(3.15)***		(3.05)***
Log K*Log (N/K)								-0.110		-0.030
								(-1.75)**		(-0.48)
R2 (within)	0.0364	0.0566	0.0582	0.0779	0.0787	0.0377	0.1074	0.1206	0.1666	0.1736
R2	0.0244	0.0423	0.0419	0.0406	0.0427	0.0255	0.025	0.0394	0.0337	0.043
Obs	1917	1917	1917	1917	1917	1917	1917	1917	1917	1917

TABLE V: Investment Regression (Fixed Effect OLS)

This table reports estimates from the following investment regression:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X comprises a set of explanatory state variables, of which, $Log\ K$ represents the firm size, $Log\ (\frac{Y}{K})$ is the firm's sales to capital ratio, and $Log\ Q$ is the natural logarithm of Tobin Q which is computed as the market value of assets scaled by the book value of assets. Higher order terms and interaction terms of these state variables are also included in X under various specifications. Asterisks indicate statistically significance at the 1% (***), 5% (**) and 10% (*). t statistics from standard errors clustered by firm are in parentheses. The sample period is from 20000-2012 including only manufacturing firms.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log Q	0.004	-0.019		-0.045	-0.029	0.020	-0.040	-0.038	0.070
	(0.370)	(-0.11)		(-0.42)	(-0.27)	(0.120)	(-0.38)	(-0.36)	(0.410)
(Log Q)^2		0.031				-0.091			-0.124
		(0.220)				(-0.65)			(-0.89)
(Log Q)^3		-0.001				0.020			0.021
		(-0.04)				(0.700)			(0.740)
Log (Y/K)			-0.246	-0.247	0.439	0.445	-0.484	-0.417	-0.439
			(-2.56)***	(-2.56)***	(0.940)	(0.950)	(-4.27)***	(-0.74)	(-0.77)
Log K			-2.186	-2.192	-1.668	-1.674	1.145	1.251	1.328
			(-4.11)***	(-4.12)***	(-2.62)***	(-2.62)***	(0.510)	(0.520)	(0.550)
(Log (Y/K))^2			0.018	0.017	-0.001	-0.002	-0.051	-0.051	-0.054
			(0.960)	(0.940)	(-0.05)	(-0.10)	(-1.97)**	(-1.95)**	(-2.03)**
(Log (K))^2			0.055	0.055	0.039	0.039	-0.171	-0.177	-0.184
			(3.08)***	(3.08)***	(1.84)**	(1.83)**	(-1.11)	(-1.10)	(-1.14)
(Log (Y/K))^3							0.017	0.017	0.017
							(3.89)***	(3.44)***	(3.47)***
(Log (K))^3							0.005	0.005	0.005
							(1.390)	(1.380)	(1.430)
Log (Y/K)*Log K					-0.049	-0.050		-0.005	-0.004
					(0.133)	(-1.51)*		(-0.12)	(-0.09)
R2 (within)	0.002	0.003	0.054	0.054	0.056	0.056	0.067	0.067	0.068
R2	0.000	0.001	0.040	0.040	0.035	0.034	0.036	0.035	0.035
Obs	1843	1843	1843	1843	1843	1843	1843	1843	1843

<u>TABLE VI</u>: Investment Regression (First Difference OLS)

This table reports estimates from the following investment regression:

$$\Delta\frac{I_{it+1}}{K_{it}} = \alpha + \beta\Delta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the first difference in end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X comprises a set of explanatory state variables in their first difference, of which, $Log\ K$ represents the firm size, $Log\ (\frac{Y}{K})$ is the firm's sales to capital ratio, and $Log\ Q$ is the natural logarithm of the Tobin Q which is computed as the market value of assets scaled by the book value of assets. Higher order terms and interaction terms of these state variables are also included in X under various specifications. Asterisks indicate statistically significance at the 1% (***), 5% (**) and 10% (*). t statistics from standard errors clustered by firm are in parentheses. The sample period is from 20000-2012 including only manufacturing firms.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log Q	-0.084	-0.167		0.000	0.007	0.006	0.019	0.020	0.071
	(-0.44)	(-0.43)		(-0.00)	-0.050	-0.030	-0.130	-0.150	-0.320
(Log Q)^2		0.044				-0.060			-0.096
		-0.200				(-0.35)			(-0.53)
(Log Q)^3		0.001				0.017			0.019
		-0.020				-0.590			-0.580
Log (Y/K)			-0.350	-0.350	0.830	0.841	-0.751	-0.589	-0.568
			(-1.35)	(-1.38)	-1.040	-1.060	(-1.36)	(-0.23)	(-0.22)
Log K			-3.139	-3.139	-2.146	-2.112	2.015	2.272	2.420
			(-1.40)	(-1.42)	(-1.31)	(-1.29)	-0.350	-0.260	-0.270
(Log (Y/K))^2			0.009	0.009	-0.023	-0.023	-0.073	-0.075	-0.076
			-0.140	-0.140	(-0.33)	(-0.33)	(-1.11)	(-1.09)	(-1.12)
(Log K)^2			0.076	0.076	0.043	0.042	-0.265	-0.279	-0.288
			-1.410	-1.420	-1.110	-1.080	(-0.56)	(-0.44)	(-0.46)
(Log (Y/K))^3							0.024	0.023	0.023
							-1.020	-0.800	-0.800
(Log K)^3							0.007	0.007	0.007
							-0.630	-0.530	-0.540
Log (Y/K)*Log K					-0.085	-0.085		-0.011	-0.012
					(-1.23)	(-1.24)		(-0.07)	(-0.08)
R2	0.0003	0.0008	0.0725	0.0725	0.0763	0.0766	0.093	0.093	0.0933
Obs	1028	1028	1028	1028	1028	1028	1028	1028	1028

TABLE VII: Cash Flow

This table reports estimates from the following investment regression:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X comprises a set of explanatory state variables, of which, $Log\ K$ represents the firm size, and $Log\ (\frac{CF}{K})$ is the firm's cash flow to capital ratio. Higher order terms and interaction terms of these state variables are also included in X under various specifications. Asterisks indicate statistically significance at the 1% (***), 5% (**) and 10% (*). t statistics from standard errors clustered by firm are in parentheses. The sample period is from 20000-2012 including only manufacturing firms.

In this regression, I specifically use three different measures of cash flow which are described shortly as follows:

(1) - (4): Cash Flow = Earnings Before Extraordinary Items + Depreciations.

(5) - (8): Cash Flow = Funds From Operation - Non Operating Income + Interest + Related Expenses.

(9) - (12): Cash Flow = Operating Income + Depreciation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log (CF/K)		0.113	-0.209	-1.68		0.003	-0.0062	-0.1363		0.03196	0.0509	0.0297
		(2.52)**	(-4.63)***	(-5.74)***		(0.15)	(-0.20)	(-0.74)		(1.69)	(1.76)	(0.22)
Log (CF/K)^2			0.152	0.195			0.006	0.011			-0.010	-0.009
			(14.4)***	(14.56)***			(0.63)	(0.94)			(-1.0)	(-0.82)
Log (CF/K)^3			0.051	0.053			0.002	0.003			-0.003	-0.003
			(20.3)***	(21.21)***			(0.95)	(1.13)			(-1.9)**	(-1.89)**
Log K	-2.43	-5.04	-9.21	-10.65	-41.90	-4.31	-4.02	-4.14	-2.68	-8.19	-9.09	-9.13
	(-1.12)	(-1.58)*	(-3.89)***	(-4.53)***	(-18.)***	(-4.08)***	(-3.59)***	(-3.66)***	(-1.25)	(-6.71)***	(-6.4)***	(-6.37)***
(Log K)^2	0.062	0.154	0.594	0.644	2.780	0.258	0.241	0.247	0.081	0.500	0.553	0.555
	(0.41)	(0.74)	(3.83)***	(4.2)***	(17.7)***	(3.67)***	(3.31)***	(3.37)***	(0.55)	(6.41)***	(6.29)***	(6.25)***
(Log K)^3	0.0002	-0.0005	-0.0126	-0.0129	-0.0600	-0.0050	-0.0047	-0.0048	-0.0002	-0.0099	-0.0109	-0.0109
	(0.07)	(-0.12)	(-3.77)***	(-3.90)***	(-16.)***	(-3.28)***	(-3.01)***	(-3.05)***	(-0.06)	(-6.06)***	(-6.1)***	(-6.04)***
Log (CF/K)*Log K				0.087				0.0081				0.0014
				(5.08)***				(0.72)				(0.16)
R2 (within)	0.052	0.1551	0.5377	0.5521	0.236	0.0328	0.0337	0.0342	0.0504	0.0696	0.074	0.0745
R2	0.04	0.0862	0.1925	0.2276	0.023	0.0273	0.031	0.0319	0.0395	0.0125	0.014	0.0142
Obs	1894	1510	1510	1510	2222	1783	1783	1783	1917	1523	1523	1523

TABLE VIII: Leverage

This table reports estimates from the following investment regression:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X comprises a set of explanatory state variables, of which, $Log\ K$ represents the firm size, $Log\ (\frac{Y}{K})$ is the firm's sales to capital ratio and $Log\ (\frac{B}{K})$ is the firm's leverage to capital ratio. Higher order terms and interaction terms of these state variables are also included in X under various specifications. Asterisks indicate statistically significance at the 1% (***), 5% (**) and 10% (*). t statistics from standard errors clustered by firm are in parentheses. The sample period is from 20000-2012 including only manufacturing firms.

In this regression, I specifically use two different measures of leverages which are described shortly as follows:

(1) - (5): Debt = Short term debt + Long term debt.

(6) - (10): Debt = Total debt - Cash and short term investment.

=>The leverage ratio is computed as debt divided by firm's total assets.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log (Y/K)	-0.033	-0.165	-0.323	2.953	2.293	-0.033	0.358	0.353	1.180	0.941
	(-0.69)	(-1.35)	(-2.71)***	(4.33)***	(3.28)***	(-0.69)	(1.390)	(1.380)	(1.150)	(0.910)
(Log (Y/K))^2	0.036	0.045	-0.012	0.016	-0.013	0.036	-0.440	-0.503	-0.440	-0.465
	(1.97)**	(1.44)*	(-0.40)	(0.520)	(-0.42)	(1.97)**	(-3.93)***	(-4.47)***	(-3.88)***	(-4.06)***
(Log (Y/K))^3	0.000	0.004	0.019	0.009	0.017	0.000	0.066	0.076	0.078	0.081
	(0.150)	(0.750)	(4.01)***	(1.74)**	(3.14)***	(0.150)	(5.6)***	(6.29)***	(6.46)***	(6.66)***
Log K	-7.066	-33.488	-34.923	-32.276	-32.469	-7.066	-5.981	-11.202	-10.254	-11.769
	(-13.35)***	(-13.79)***	(-14.86)***	(-12.06)***	(-12.25)***	(-13.35)***	(-2.27)**	(-3.75)***	(-3.36)***	(-3.70)***
(Log K)^2	0.404	2.188	2.194	2.083	2.076	0.404	0.411	0.681	0.668	0.741
	(12.52)***	(13.09)***	(13.59)***	(11.88)***	(11.96)***	(12.52)***	(2.25)**	(3.48)***	(3.35)***	(3.64)***
(Log K)^3	-0.008	-0.047	-0.046	-0.044	-0.044	-0.008	-0.009	-0.014	-0.014	-0.015
	(-11.74)***	(-12.33)***	(-12.41)***	(-11.38)***	(-11.37)***	(-11.74)***	(-2.22)**	(-3.24)***	(-3.22)***	(-3.46)***
Log (B/K)		-0.132	0.194	-1.763	-0.593		-0.027	-0.022	0.337	0.505
		(-2.12)**	(-2.6)***	(-4.51)***	(-1.23)		(-0.47)	(-0.29)	(0.670)	(0.990)
(Log (B/K)^2			-0.101		-0.048			-0.065		-0.020
			(-7.94)***		(-2.67)***			(-3.24)***		(-0.81)
(Log (B/K)^3)			-0.020		-0.015			-0.012		-0.007
			(-8.57)***		(-5.75)***			(-3.11)***		(-1.75)**
Log (Y/K)*Log K				-0.204	-0.167				-0.047	-0.034
				(-4.59)***	(-3.68)***				(-0.82)	(-0.58)
Log (B/K)*Log (Y/K)				-0.172	-0.133				-0.236	-0.215
				(-5.03)***	(-3.75)***				(-4.09)***	(-3.37)***
Log (B/K)*Log K				0.129	0.064				0.002	-0.007
				(5.42)***	(2.14)**				(0.080)	(-0.24)
R2 (within)	0.1556	0.1829	0.2387	0.2345	0.2514	0.1556	0.1024	0.1164	0.1256	0.129
R2	0.151	0.0337	0.0563	0.0508	0.0572	0.151	0.0025	0.0229	0.0104	0.0202
Obs	2464	2459	2459	2459	2459	2464	1553	1553	1553	1553

TABLE IX: Lagged Investment

This table reports estimates from the following investment regression:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X comprises a set of explanatory state variables, of which, $Lagged\ \frac{I}{K}$ is the lagged investment instrumented using prior two lags of its first difference, $Log\ K$ represents the firm size, $Log\ (\frac{Y}{K})$ is the firm's sales to capital ratio, $Log\ (\frac{CF}{K})$ is the firm's cash flow to capital ratio and $Log\ Q$ is the natural logarithm of the Tobin Q which is computed as the market value of assets scaled by the book value of assets. Higher order terms and interaction terms of these state variables are also included in X under various specifications. Asterisks indicate statistically significance at the 1% (***), 5% (**) and 10% (*). t statistics from standard errors clustered by firm are in parentheses. The sample period is from 20000-2012 including only manufacturing firms.

In this regression, I also use three different measures of cash flow which are described shortly as follows:

(1) - (4): Cash Flow = Earnings Before Extraordinary Items + Depreciations.

(5) - (8): Cash Flow = Funds From Operation - Non Operating Income + Interest + Related Expenses.

(9) - (12): Cash Flow = Operating Income + Depreciation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lagged (I/K)	1.252		0.052	1.226	0.350		-0.013	0.263	0.400		0.054	0.313
	(5.31)***		(0.38)	(5.49)***	(2.07)**		(-0.14)	(1.59)**	(2.35)**		(0.40)	(1.91)**
Log (Y/K)		-0.254	-0.031	0.272	0.458	-0.116	-0.085	0.141		-0.240	-0.014	0.305
		(-2.61)***	(-0.39)	(0.69)	(3.02)***	(-0.97)	(-1.14)	(0.35)		(-2.5)***	(-0.19)	(0.93)
(Log (Y/K))^2		0.018	0.021	-0.034	-0.343	0.121	0.029	-0.040		0.018	0.018	-0.240
		(0.95)	(1.14)	(-0.42)	(-2.89)***	(5.26)***	(1.51)*	(-0.54)		(0.96)	(1.01)	(-3.73)***
Log K		-2.264	-0.710	-5.489	0.217	-3.870	-1.000	-4.855		-2.186	-0.714	-4.586
		(-4.20)***	(-1.74)**	(-4.40)***	(3.34)***	(-5.56)***	(-2.37)**	(-4.80)***		(-4.11)***	(-1.76)**	(-4.96)***
(Log K)^2		0.057	0.025	0.165	0.080	0.136	0.034	0.147		0.055	0.026	0.131
		(3.16)***	(1.77)**	(4.62)***	(4.08)***	(5.95)***	(2.27)**	(4.57)***		(3.08)***	(1.81)**	(4.53)***
Log Q	1.160			1.062				0.680	0.288			0.568
	(5.44)***			(5.29)***				(4.16)***	(2.09)**			(3.8)***
(Log Q)^2	-0.964			-0.806				-0.396	-0.349			-0.512
	(-5.82)***			(-5.09)***				(-3.15)***	(-3.50)***			(-4.80)***
Log (CF/K)	0.060			0.039				0.095	0.457			0.571
	(1.26)			(0.80)				(1.16)	(6.67)***			(6.11)***
(Log (CF/K))^2	0.051			0.045				0.057	0.167			0.193
	(2.6)***			(2.38)**				(2.58)***	(7.57)***			(7.3)***
R2 (within)	0.2297	0.0549	0.0148	0.3362	0.1107	0.0964	0.0234	0.1901	0.2481	0.0535	0.0141	0.3322
R2	0.2735	0.0405	0.0002	0.1311	0.5855	0.0062	0.0011	0.0579	0.4642	0.0399	0.0001	0.1266
Obs	810	1828	1018	810	940	2099	1140	940	828	1843	1028	828

Table X: Alternative Panels

The table reports estimates from the following investment regression:

$$\frac{I_{it+1}}{K_{it}} = \alpha + \beta X_{it} + \delta_i + \eta_t + \varepsilon_{it+1}$$

Where the dependent variable is the end of year capital expenditures scaled by beginning of year property, plant and equipment, and δ_i, η_t is the firm and year fixed effect respectively. Meanwhile, X comprises a set of explanatory state variables, of which, $Log\ K$ represents the firm size, $Log\ (\frac{Y}{K})$ is the firm's sales to capital ratio, and $Log\ (\frac{N}{K})$ is the firm's employment to capital ratio. Higher order terms and interaction terms of these state variables are also included in X under various specifications. Asterisks indicate statistically significance at the 1% (***), 5% (**)

and 10% (*). t statistics from standard errors clustered by firm are in parentheses. The sample period is from 20000-2012 including not only manufacturing firms but also those from other industries.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log (Y/K)	-1.077	-1.075	-11.737	-1.098	-15.175	-0.978	-0.984	-13.517	-0.610	-17.785
	(-0.57)	(-0.55)	(-1.07)	(-0.47)	(-1.30)	(-0.51)	(-0.50)	(-1.22)	(-0.26)	(-1.51)*
Log K	-3.097	-18.136	-28.818	-59.941	-78.764	-3.806	-13.396	-11.602	-33.766	-31.967
	(-1.52)*	(-1.85)**	(-1.97)**	(-1.66)*	(-2.01)**	(-1.27)	(-1.13)	(-0.63)	(-0.90)	(-0.76)
Log (N/K)						-0.812	3.231	18.403	13.815	35.911
						(-0.32)	(0.600)	(1.52)*	(2.02)**	(2.65)***
(Log (Y/K))^2		-0.065	0.189	-0.111	0.186		-0.068	0.290	-0.108	0.336
		(-0.23)	(0.500)	(-0.37)	(0.490)		(-0.24)	(0.750)	(-0.36)	(0.870)
(Log (K))^2		0.520	0.861	3.452	4.258		0.355	-0.224	1.674	1.077
		(1.59)*	(1.81)**	(1.410)	(1.68)**		(0.930)	(-0.25)	(0.660)	(0.390)
(Log (N/K))^2							0.198	-0.330	1.862	1.675
							(0.850)	(-0.53)	(2.62)***	(1.77)**
(Log (Y/K))^3				0.001	0.011				0.000	0.021
				(0.030)	(0.280)				(-0.01)	(0.510)
(Log (K))^3				-0.066	-0.075				-0.030	-0.031
				(-1.21)	(-1.36)				(-0.53)	(-0.54)
(Log (N/K))^3									0.062	0.072
									(2.45)**	(2.78)***
Log (Y/K)*Log (K)			0.731		0.942			0.528		0.484
			(0.990)		(1.230)			(0.610)		(0.550)
Log(Y/K)*Log(N/K)								-0.522		-1.028
								(-0.79)		(-1.49)*
Log K*Log (N/K)								-1.631		-1.812
								(-1.21)		(-1.35)
R2 (within)	0.0015	0.0021	0.0023	0.0025	0.0028	0.002	0.0023	0.003	0.0041	0.0053
R2	0.002	0.0058	0.0018	0.01	0.0074	0.002	0.0066	0.0016	0.0089	0.0047
Obs	7254	7254	7254	7254	7254	7254	7254	7254	7254	7254

TABLE XI: Variance Decomposition

This table reports variance decomposition for various investment specifications. The Type III partial sum of squares is computed for each effect in the model and then normalized by the sum across the effects, forcing each column to sum to one. Firm FE are firm fixed effects. Year FE are year fixed effects. Sales and Size are the state variables comprising of Firm Size, $Log\ K$, Sales to Capital Ratio, $Log\ (\frac{Y}{K})$ and their respective higher order terms. Other effects also included in this variance analysis are Tobin Q, Cash Flow, Net Leverage and Lagged Investment.

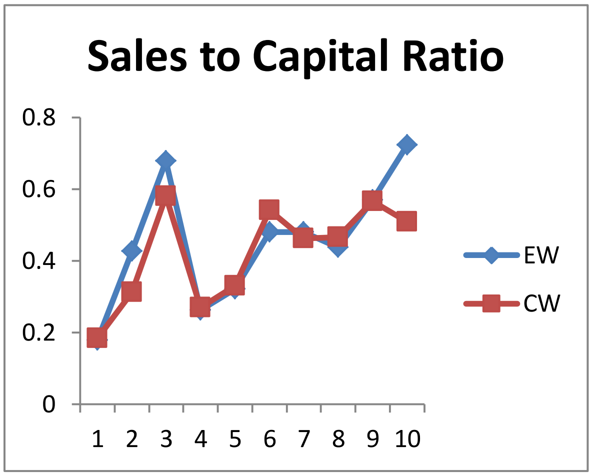
	(1)	(2)	(3)	(4)
	Panel A: Fixed Effect Estimators			
Firm FE	0.248581	0.195391	0.001173	0.000886
Year FE	0.751419	0.641678	5.32E-05	0.000746
Tobin Q		0.162931		0.015738
Sales & Size			0.998774	0.98263
R2	0.0018	0.0029	0.1491	0.1569

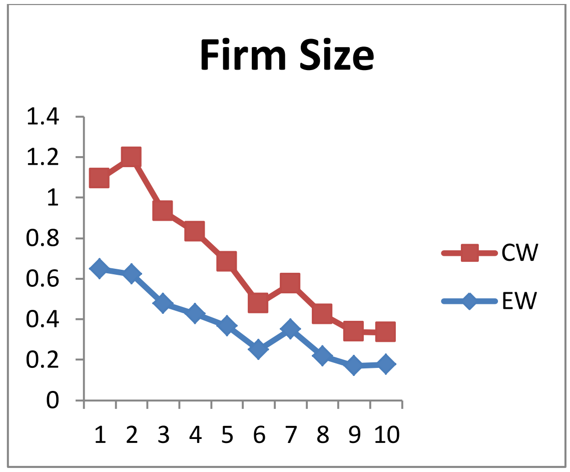
	(1)	(2)	(3)	(4)
	Panel B: First Difference Estimators			
Year FE	1	0.232682	0.119719	0.083118
Tobin Q		0.767318		0.153487
Sales & Size			0.880281	0.763395
R2	0.0014	0.0024	0.0423	0.0449

	(1)	(2)	(3)	(4)	(5)	(6)
	Panel C: Extended Effects					
Firm FE	0.612179	0.002469	0.002081	0.000935	0.001017	0.000708
Year FE	0.387821	0.022541	0.020692	0.009869	0.023973	0.007626
Sales & Size		0.974989	0.933497		0.968839	0.244538
Tobin Q			0.043729			
Cash Flow & Size				0.989197		
Net Leverage					0.006171	
Lagged Investment						0.747127
R2	0.0014	0.1051	0.1070	0.2354	0.1086	0.1469

Figure 1

This figure plots the changes in average investment rate conditional on firm size, sales to capital ratio and employment to capital ratio. Equal weighted (EW) and capital weighted (CW) average methods are alternatively used to compute the average investment rate. The result is taken directly single sort state portfolio analysis and presented in more visual format.





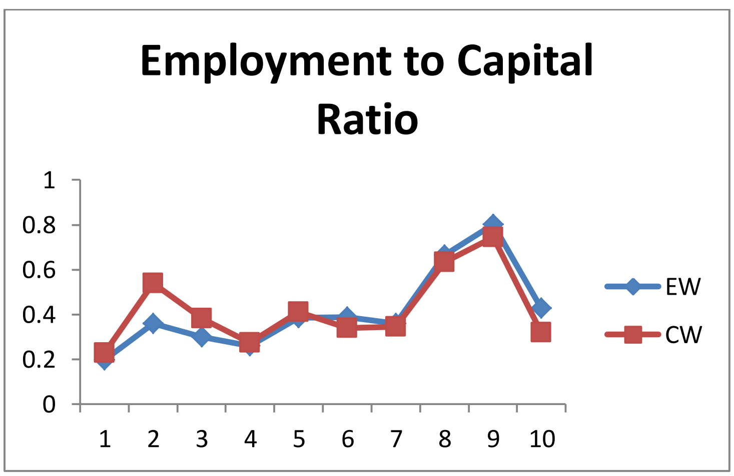


Figure 2

This figure plots the changes in average investment rate that is double sorted on the empirical distribution of the sales to capital ratio and employment to capital ratio conditional on firm size. The result is taken directly double sorted state portfolio analysis and presented in more visual format in which size 1 represent the smallest firm size quintile and size 5 represent the largest firm size quintile.