Essays in Corporate Finance

by

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Abstract

China has been growing rapidly over the last decades. The private sector is the driving force of this growth. This thesis focuses on firm-level investment and cash holdings in China, and the chapters are structured around the following issues.

1. Why do private firms grow so fast when they are more financially constrained?

In Chapter 3, we use a panel of over 600,000 firms of different ownership types from 1998 to 2007 to find the link between investment opportunities and financial constraints. The main finding indicates that private firms, which are more likely to be financially constrained, have high investment-investment opportunity sensitivity. Furthermore, this sensitivity is relatively lower for state-owned firms in China. This shows that constrained firms value investment opportunities more than unconstrained firms.

To better measure investment opportunities, we attempt to improve the Q model by considering supply and demand sides simultaneously. When we capture q from the supply side and the demand side, we find that various types of firms respond differently towards different opportunity shocks.

2. In China, there are many firms whose cash flow is far greater than their fixed capital investment. Why is their investment still sensitive to cash flow?

To explain this, in Chapter 4, we attempt to introduce a new channel to find how cash flow affects firm-level investment. We use a dynamic structural model and take uncertainty and ambiguity aversion into consideration. We find that uncertainty and ambiguity aversion will make investment less sensitive to investment opportunities. However, investment-cash flow sensitivity will increase when uncertainty is high. This suggests that investment cash flow sensitivities could still be high even when the firms are not financially constrained.

3. Why do firms in China hold so much cash? How can managers' confidence affect

corporate cash holdings?

In Chapter 5, we analyse corporate cash holdings in China. Firms hold cash for precautionary reasons, to hedge frictions such as financing constraints and uncertainty. In addition, firms may act differently if they are confident or not. In order to determine how confidence shocks affect precautionary savings, we develop a dynamic model taking financing constraints, uncertainty, adjustment costs and confidence shocks into consideration.

We find that without confidence shocks, firms will save money in bad times and invest in good times to maximise their value. However, if managers lose their confidence, they tend to save money in good times to use in bad times, to hedge risks and financing constraint problems. This can help explain why people find different results on the cash flow sensitivity of cash. Empirically, we use a panel of Chinese listed firms. The results show that firms in China save more money in good times, and the confidence shock channel can significantly affect firms' cash holdings policy.

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Whatever I achieve today, I owe to my parents and grandparents. I am very grateful for their unconditional love and support.

Dedication

This dissertation is dedicated to my parents.

Declaration

I declare that, except where explicit reference is made to the contribution of others, that this dissertation is the result of my own work and has not been submitted for any other degree at the University of Glasgow or any other institution.

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Chapter 1

Introduction

Capital markets are imperfect. There are many frictions. In last few decades, financing constraints are highlighted as an important problem in corporate finance studies. In short, financing constraints suggest that firms cannot be funded as they desire. Based on the facts of financing constraints, if a firm is highly uncertain on their future, firm's decisions can be distorted. Building on the literature, our thesis aims to find how to apply these theories to Chinese firms.

Firstly there is a general questions to think about: why do we study corporate finance with Chinese firms?

China is an ideal laboratory for studying how different frictions affect firm's decisions. When managers making decisions, they need to think over the frictions they are facing. In China, there are two main sectors, state owned sector and private sector [1]. Since they are owned by different shareholders, they have different goals and face different frictions. For example, state owned firms are more likely to be affected by government intervention (Firth et al., 2012; Chen et al., 2011). They may have political objectives. However, although the legal, regulation environment for private economic activity in China gradually improved in last decades, private firms still face financing constraint problems (Lardy, 2014). Under this legal, regulation environment, firms in China need to protect themselves from frictions such as financing constraints, uncertainty, and confidence shocks [2]. In addition, a better understanding of Chinese firms and the frictions can help us to explain why China grow so fast at firm-level.

In the economic theory, financing constraints can dramatically limit firm's growth. This is because firms cannot invest some projects as they want. Empirically, Fazzari et al. (1988) suggest that financing constraints will cause investment to be sensitive to cash flow. When firms cannot get external funds, they will finance the projects with internal funds and cash flows are the resources of internal funds. However, the monotonic relationship between financing constraints and the sensitivity is weak in terms of theoretical studies. So, there are many papers suspect this evidence from different perspectives.

We will discuss the frictions, such as financing constraints, uncertainty, and adjustment costs from a basic question: what is a firm's optimal investment level? The question is attempt to be answered with the benchmark model, which links invest-

[1] Besides the state owned and private firms, there are firms with other ownerships, such as foreign firms and collective firm. We will introduce them in the following chapters.

[2] We will discuss more about the frictions in the following chapters.

ment directly to investment opportunities. However, the explanatory power of the benchmark model is weak. The main problem that it is hard to find a good proxy of investment opportunity.

Then the benchmark model develops to Q model, which use average q, also known as Tobin's q to be the proxy of investment opportunity. The advantage of this model is that it largely simplified the benchmark model, and made the benchmark model applicable. However, many empirical studies shows that the q model has many problems. One problem is the mismeasurement of q. Another doubt is that the q model itself is problematic. One reason is that the model fail to take financial market frictions into consideration. There are many empirical papers which try to improve the measurement of q. We then introduce and discuss the Euler equation model, which is also developed from the benchmark model.

Many empirical studies indicate that merely linking investment to investment opportunity cannot find optimal investment levels. Then there is another question: what can affect firm's investment behaviour? How do managers make investment decisions?

In general, we review the papers and focus on two factors, financing constraints and uncertainty. Financing constraints can make firms less sensitive to fundamentals (investment opportunities) because they may think more about their financing costs or availability. There are many theories which explain how uncertainty affect investment. Most of the theories have the same conclusion that high uncertainty will make firms underinvest. Moreover, uncertainty and financing constraint are not independent from each other, they can amplify the effects of each other.

Then, the question is how to solve financing constraints and uncertainty problems. One method is through cash holdings. We call this type of cash holdings as 'precautionary savings'. The discussions are around why firms save cash and what the optimal saving level is. We review recent papers and find that although there is no consensus, most studies agree that firms save cash for precautionary reasons and agency problems.

In China, financing constraints are believed as a severe problem. The reason is largely contributed by inefficient financial system. Allen et al. (2012) show that financial system in China is dominated by state-owned banks. Firms in the state-owned sector can raise external funds from banks, but firms in the private sector are less likely to. As such, private firms are the most financially constrained. However, the fact, as mentioned by both Allen et al. (2005) and Guariglia et al. (2011), is that private firms grow faster than state owned. Then, there is a big question: why do more financially constrained firms grow faster?

Allen et al. (2005) and Guariglia et al. (2011) give their answers to the question in terms of internal and external finance. Allen et al. (2005) suggest that private firms have alternative financing channels. For example, they can borrow money from friends, family, private borrowing institutes etc. Guariglia et al. (2011) show that private firms in China are very profitable. They can finance themselves with internal funds.

Based on previous findings, we also want to contribute to solve this question in Chapter 3. The difference is that we want to find some evidence from the fundamental part, the investment opportunity. There are two research questions: how do firms in China respond to investment opportunities and how to explain a private firm's fast growth from the fundamental perspective? In Chapter 3, we decomposed q model and measured investment opportunities from both supply side and demand side. We use total factor productivity (TFP) growth to measure investment opportunity of the supply side and use sales growth as the proxy for demand side. Then we combine TFP and sales growth to estimate a forward looking q with panel VAR, which is suggested by Gilchrist and Himmelberg (1995). This method allows us to take forward looking investment opportunities into consideration.

In the empirical section, we use a large dataset from annul survey conducted by National Bureau of Statistics (NBS) of China. The panel contains more than 600,000 firms from 1998 to 2007. The empirical results suggest that private firms show higher sensitivity to investment opportunities than SOEs. This suggest that private firms cherish investment opportunities more. Therefore private firms grow faster. In addition, we also find that firms with different ownerships show different sensitivity to investment opportunities. For example foreign firms are more sensitive to demand growth but less sensitive to TFP growth.

The contributions of this chapter are twofold. First, we explain why private firms are more financially constrained but invest more and grow faster in China. Second, we combine investment opportunities from both supply and demand side.

In Chapter 4, we discuss investment cash flow sensitivity. According to Fazzari et al. (1988), high investment cash flow sensitivity is a signal of financing constraints. However, when we take a look at relative literature using the same dataset as ours, we find that fixed investment in China on average is less than 20% of total cash flow. This means most firms' investment cannot exceeds their cash flow. In other words, they are not likely to be financially constrained. Then the question is, why is their investment still sensitive to cash flow?

Given the question above, we suggest a new channel of explaining cash flow sensitivity under the framework of uncertainty. In Chapter 4, we take ambiguity aversion into consideration. We define the ambiguity aversion according to Ilut and Schneider (2012). They suggest that when firms are ambiguity averse, they will behave as if they are going to face the worst outcomes. We apply this hypothesis to construct a dynamic structure model. We also include three types of adjustment costs, namely quadratic costs, fixed costs, and irreversibility. We assume that demand shocks are investment opportunity and the only source of uncertainty. So, the 'worst outcome' scenario in our model is the 'worst demand'. Practically, we build a ceiling of investment. That is, firms will be safe if they invest lower than that ceiling.

We then simulate the model and find that with ambiguity aversion, firms will invest according to demand when demand is low. When demand is high, firms will be more sensitive to cash flow.

We then use NBS (National Bureau of Statistics) dataset. There are 10 years, from 1998 to 2007 and more than 600,000 firms. The empirical results support our theoretical findings. That is, in China the explanatory power of investment opportunity decrease when uncertainty increase. On the other hand, firms are becoming more sensitive to cash flow when investment opportunities are high. This result can not only show that uncertainty has negative impact on investment but also proves the existence of ambiguity aversion.

Chapter 5 focuses on firm's capital structure. The key research question is: what is the firm's optimal cash holding level? It is not hard to find the answer. We can get the optimal cash holding when marginal benefit of cash equals to marginal cost of cash. Of course, maximising firm's value is not the only goal of a manager. Firms may also hold cash for agency reasons.

Although it is easy to argue that at equilibrium, marginal cost of cash holding equals to marginal benefit, there are many theories and many different findings on optimal cash holding level. The reason is because different theories define marginal benefit of cash holdings differently. For example Almeida et al. (2004) suggest that the benefit of cash is that it can be used when a firm is financially constrained. Riddick and

Whited (2009) suggest that cash can be used to solve the problems such as financing constraints and uncertainty.

In chapter 5, we decide to make some improvements base on previous literature. We take more factors into consideration. We suggest that marginal benefit of cash depends on external financing costs, uncertainty, adjustment costs, and confidence shocks. Since the first three factors have been studied before, we want to focus more on confidence shocks.

What confidence shock is and how to apply a confidence shock to our model. In our paper, we suggest that managers have different confidence overtime. They will behave differently when they are confident or not. Generally speaking, when making cash holding decisions, unconfident managers may worry about the income shocks when uncertainty is high. So they want to use cash to hedge income shocks. To what extent they want to use cash to hedge depends on their confidence.

We build a dynamic structure model according to our hypothesis and get the policy function with value function iteration. We then simulate the model. We find that firm's cash holding decisions are sensitive to manager's confidence. When managers are confident, they will hold cash during the bad times and use cash when investment opportunity is high. In this way they can get highest return and firm value. However, when managers are unconfident, they will save cash in good times, and use in bad times. Because in bad times, firm need money to survive.

We use the real company data for empirical study to check whether or not confidence shock can affect cash holdings. The dataset is an unbalanced panel of 1,478 listed firms from 1998 to 2010. Our empirical result suggest that in China the cash-cash flow sensitivity is positive, which suggest that firms in China would like to hold cash in good times and use in bad times. Then we add uncertainty into our empirical estimations. We find that uncertainty will make firms save more cash, and make firm's cash holdings more sensitive to cash flows. Finally, we estimate the value of cash holdings according to Faulkender and Wang (2006). We find that, holding uncertainty constant, marginal value of cash holdings decrease more after the financial crisis. Managers want to hold more excess cash because they are less confident.

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Chapter 2

Literature Review

2.1 Introduction

The discussion on financing constraints and uncertainty has a long history, and is still important in corporate finance. Because of financing constraints and uncertainty, firms must deal with complex investment, liquidity management, risk management issues.

The chapter begins with a simple question: what is a firm's optimal investment level? To answer this question, researchers build a benchmark model which links investment and marginal revenue product of capital. To get the result, there are two necessary assumptions, 'firm value maximization' and 'convex adjustment costs'. Based on the benchmark model, this chapter reviews the development of theoretical investment literature, and discusses empirical evidence. After reviewing the models, this chapter also reviews and surveys the areas of investment and cash holding decisions under financing constraints and uncertainty. This chapter ends with a review of investment and cash holdings literature in China.

2.2 Firm-level investment theories, evidence and discussions

2.2.1 The benchmark model

In 1993, Chirinko explains the benchmark dynamic model explicitly in his survey paper. The dynamic investment model begins by an assumption that firms make their investment decisions through maximising firm value which could be measured by discounted sum of net revenue. In addition, firms are price takers in both input and output market, and a firm revenue is affected by adjustment costs and technology shocks. By reconciling the works by Bond and Van Reenen (2007) and Chirinko (1993), a firm's net revenue is

$$\Pi_t(K_t, L_t, I_t) = p_t \left[F\left(L_t, K_t : \tau_t\right) - G(I_t, K_t : \tau_t)\right] - w_t L_t - p_t^K I_t \tag{2.1}$$

Π_t is a firm's net revenue. p_t is the price of output. $F\left(L_t, K_t : \tau_t\right)$is output which is a function of labour (L_t), capital(K_t) and stochastic technology shocks(τ_t). Capital is usually assumed to be quasi-fixed, which means a firm which adjusts its capital stock will suffer an adjustment cost, $G(I_t, K_t : \tau_t)$. w_t is price of labour and p_t^K is price of investment. Firms maximise their values by maximising the sum of discounted net revenues,

$$V_t(K_{t-1}) = \sum_{s=t}^{\infty}(1+r)^{(s-t)} \left\{[F(L_s, K_s : \tau_s) - G(I_s, K_s : \tau_s)] - w_s L_s - p_s^K I_s\right\} \tag{2.2}$$

r is the discount rate which is defined as a constant value. A firm's value could be simplified as,

$$V_t(K_{t-1}) = \max_{I_t, L_t} \Pi_t(K_t, L_t, I_t) + \beta_{t+1} E_t\left[V_{t+1}(K_t)\right] \tag{2.3}$$

$\beta_t = 1/(1+r)$ is a firm's discount factor. The maximised value is constrained by capital accumulation function,

$$I_t = K_t - (1-\delta)K_{t-1} \tag{2.4}$$

The maximization problem with the constraint of Equation (2.4) can be solved with the Lagrange Multiplier. The solution can be characterised by the first order conditions:

$$-\left(\frac{\partial \Pi_t}{\partial I_t}\right) = \lambda_t \tag{2.5}$$

$$\lambda_t = \left(\frac{\partial \Pi_t}{\partial K_t}\right) + (1-\delta)\beta_{t+1} E[\lambda_{t+1}] \tag{2.6}$$

$\lambda_t = \frac{1}{1-\delta}\left(\frac{\partial V_t}{\partial K_{t-1}}\right)$ is the shadow value of inheriting one additional unit of capital in period t. The Equation (2.6) could be transformed by repeated substitutions, which can turn into,

$$\lambda_t = E_t\left[\sum_{s=0}^{\infty}(1-\delta)^s \beta_{t+s}\left(\frac{\partial \Pi_{t+s}}{\partial K_{t+s}}\right)\right] \tag{2.7}$$

Partial differentiating Π_t in Equation (2.7) with respect to I_t, we will have,

$$\frac{\partial \Pi_t}{\partial I_t} = -p_t\left(\frac{\partial G}{\partial I_t}\right) - p_t^k = \lambda_t \tag{2.8}$$

To obtain the benchmark model, we need to know how the adjustment costs are defined. One of the most popular assumption is that adjustment costs are quadratic in gross investment, homogeneous of degree one in I_t and K_t and affected by technology shock, τ_t,

$$G(I_t, K_t) = \frac{b}{2}\left[\left(\frac{I_t}{K_t}\right) - a - \tau - e_t\right]^2 K_t \tag{2.9}$$

a is some rate of investment and e_t is the error term. Then substitute the adjustment cost in Equation (2.9) into (2.8), the benchmark model can be derived as,

$$\frac{I_t}{K_t} = a + \frac{1}{b}\left[\left(\frac{\lambda_t}{p_t^k} - 1\right)\frac{p_t^k}{p_t}\right] + \tau + e_t \tag{2.10}$$

As is shown in the Equation (2.7), λ is the sum of discounted marginal revenue product of capital. This means that firm investment decisions depend on expected investment opportunities.

2.2.2 Investment and Q model

The Q model

The benchmark model is problematic because λ_t is unobservable. One way to solve this problem is using Tobin's Q. That is using market information to estimate λ_i.

Marginal q is the ratio of the discounted future revenues from an additional unit capital to purchase cost,

$$q_t = \frac{\lambda_i}{p_t^k} \tag{2.11}$$

Since marginal q is unobservable, Hayashi (1982) uses an observable 'average q' to replace it. There are three conditions: production and adjustment cost technologies have homogeneous return to scale; the firms are price taker [1]; and net revenue function is homogeneous of degree one. We can multiply I_i on both sides of Equation (2.8) and K_i on both sides of Equation (2.9) and combine them together to get

$$\lambda_t(K_t - I_t) = \left(\frac{\partial \Pi_t}{\partial I_t}\right) I_t + \left(\frac{\partial \Pi_t}{\partial K_t}\right) K_t + (1-\delta)\beta_{t+1} E[\lambda_{t+1}] K_t \tag{2.12}$$

If we assume $\left(\frac{\partial \Pi_t}{\partial L_t}\right) = 0$ for the variable factors of production, we can rewrite Equation (2.12) as

[1] The market are assumed to be competitive

$$(1-\delta)\lambda_t K_{t-1} = \Pi_t + \beta_{t+1} E_t[(1-\delta)\lambda_{t+1} K_t] \tag{2.13}$$

Solving forward by repeat substitution gives,

$$(1-\delta)\lambda_t K_{t-1} = E_t\left[\sum_{s=0}^{\infty} \beta_{t+s}\Pi_{t+s}\right] = V_t \tag{2.14}$$

where V_t is the maximised value of the firm. Thus we have:

$$\lambda_t = \frac{V_t}{(1-\delta)K_{t-1}}, \tag{2.15}$$

or

$$q_t = \frac{V_t}{(1-\delta)p_t^k K_{t-1}}.$$

Substituting marginal q with average q (or Tobin's q (Brainard and Tobin, 1968; Tobin, 1969)), the basic Q investment model is,

$$\begin{aligned} \left(\frac{I_t}{K_t}\right) &= a + \frac{1}{b}\left[\left(\frac{V_t}{(1-\delta)p_t^k K_{t-1}}\right)\frac{p_t^k}{p_t}\right] + \tau + e_t \\ &= a + \frac{1}{b}Q_t + \tau + e_t \end{aligned} \tag{2.16}$$

The basic Q model indicates that investment is linearly related to the expectation of profitability. If the stock market is effective, then Tobin's q can be correctly specified. It will contain all the relevant information and it should be a sufficient statistic for investment. Q model is one of the most popular models in studying investment behaviour. The advantage is that it provides researchers a good method to measure the expected variables. That is, the model is forward looking.

The Q model: evidence and Discussion

It is undeniable that the Q model and Tobin's q dramatically simplified the measurement of investment opportunity and made it observable. However, many empirical studies shows that the Q model is problematic. Bond et al. (2004) document that under certain assumptions about the firm's technology and competitive environment, in the Q model, average q should be a sufficient statistic for investment. However, if the conditions are not satisfied, the average q would fail to capture relevant information about the expected future profitability. Erickson and Whited (2000) summarize the disappointing points of empirical studies. Firstly, as is shown from many papers, the estimation's fit of goodness (R^2) is very low. This suggests that average q has little explanatory power. Many empirical studies also found that fitted models imply highly implausible adjustment costs and speeds. Finally, to predict marginal q, factors like output, sales, and cash flow which affect firm's investment decisions should not be ignored.

As is shown by Fazzari et al. (1988b), the regressor of cash flow has a high explanatory power. Erickson and Whited (2000) suggests three possible reasons. Firstly, the marginal q is mis-specified. Alternatively, if marginal q is correctly captured and the Q model is right, we should consider if the econometric assumptions are right. Or, if average q is a perfect proxy for marginal q; and the econometric assumptions are correct, then, the Q model is problematic. That is to say, firms do not care much about expected profit when making investment decisions.

As most researchers suspect, the main problem with Q model is the mismeasurement of marginal q. If the marginal q is mismeasured, the OLS coefficients estimated for the mismeasured regressor is biased towards zero (Erickson and Whited, 2000). Thus, irrelevant variables may appear significant. The mismeasurement problem stems from the reliability of market mechanism in pricing financial assets, that is, there are 'bubbles' in stock prices (Bond et al., 2004; Gilchrist et al., 2005). Besides, stock price is too volatile and contains too much noise (Bond and Cummins, 2001; Cummins et al., 2006). Chirinko (1993) also questions average q from the measurement problem of firm's capital replacement costs and the tax and non-tax component of P_t^k. Bakke and Whited (2010) find that a firm's investment will respond to stock market price only when the price reveals legitimate information and relies on equity financing.

In addition to the substitution of average q and marginal q provided by Hayashi (1982), many people suggest a lot of alternative methods to improve the measurement of marginal q.

Firstly, it seems plausible that augmented Q with lagged variables(ratio of sales to beginning-of-period capital) improves the performance of average Q. Yet, it is doubted, because it constitutes a far smaller information set than firms actually use to form expectations of returns to investment.

Second, some researchers use time series methods (e.g. VAR model) to simulate Q with lagged variables. However, the problem of the simulated q is that it forces the relationship between lagged variables and future investment returns to be the same although it is simulated with many variables.

Gilchrist and Himmelberg (1995) empirically examine the role of cash flow with Q model. The authors also consider the effectiveness of Tobin's Q.To solve this problem they construct a proxy for the expected discounted stream of marginal profits to investment, the fundamental Q. The fundamental Q is forecasted with vector auto-regression (VAR) method. This is because they assume that a firm's profitability [2] follows a stationary stochastic process. Then the expected profit could be estimated with lagged values. Another contribution of the 'Fundamental Q' is that they include cash flow as one of the observable fundamentals in the VAR forecasting equations. Thus, the 'Fundamental Q' will capture all the information about the profitability in future. This can isolate the role of cash flow as a forward looking investment opportunity.

Gilchrist and Himmelberg (1998) discuss the differences between marginal and average return to capital. Since we lack good measures of the marginal q, the investment literature often use average q (or average return to capital.) The problem of using this method is that the average q contains a lot of information of financial health of the firm. The information could also affect investment. They use two methods to solve this problem. The first method is using panal-data VARs. They identify that shocks to cash flow that are orthogonal to MPK. The result implies that the response of investment to cash flow cannot be attributed to average q. They also use panel-data VARs to estimate the investment model with financial frictions. They find that investment shows excessive sensitivity to the present value of financial variables because the values are influenced by financial frictions.

Bond and Cummins (2001) and Cummins et al. (2006) use the Q theory and examine whether internal funds significantly affect investment behaviour when the q is correctly captured. They introduce a measure of fundamentals based on securities analysts' earnings forecasts ($\widehat{Q}$) in place of the conventional measure of average q based on share price data. They assume that $E_t^c[\Pi_{i,t+s}^{\alpha}]$ is the analyst's consensus forecast of earnings. Then the firm's estimated value is,

$$\widehat{V}_{i,t} = E_t^c[\Pi_{i,t}^{\alpha} + \beta_{t+1}\Pi_{i,t+1}^{\alpha} + \cdots \beta_{t+s}\Pi_{i,t+s}^{\alpha} + \beta_{t+s+1}\widetilde{\Pi}_{i,t+s+1}]$$

β is the discount rate. $t+s$ is the most distant period for which analysts issue forecasts in period t. $\widetilde{\Pi}_{i,t+s+1}$ is an imputation for earnings in period $t+s+1$. Thus, $\widehat{Q}$ contains information of analysts' expectations which remove noise. Bond and Cummins (2001)

[2]In the paper, they use a vector of profit normalised by the capital stock.

and Cummins et al. (2006) use the same dataset, Compustat and I/B/E/S data over the 1982-1999 period. The full sample contains 11,431 observations. Empirically they use the OLS first. However, OLS estimator could be biased because Tobin's Q may be correlated with an error term. So, the OLS results are nothing more than a first pass at data that allows them to connect with prior work.

They also employ GMM estimation. The advantage of using GMM estimation is to circumvent the potential bias. On the other hand, GMM estimation could also test whether strong assumptions needed to construct real Q[3].

By comparing the GMM results, the coefficients of Real Q are larger when they remove the Tobin's Q from GMM instruments. This method provides another way to prove that the mis-specification of Tobin's Q biases the empirical results.

Carpenter and Guariglia (2008) improve the measurement q with UK firms' contracted capital expenditure. The contracted capital expenditure can capture some information that is not contained in Tobin's q. This is because the contracted investment contains information about opportunities available only to insiders. They use UK quoted company data, which is balanced and collected from Datasream. The sample they use contains 6308 observations for 693 firms over the period 1983-2000. When they estimate the q model with contracted capital expenditure, they find that the investment-cash flow sensitivity falls for large firms but remains unchanged for small firms.

[3]More specifically, in the q theory, their is a strong assumption that there should be quadratic adjustment costs. Bond and Cummins (2001) estimated the q model with GMM method. They suggested that if the measurement error of real q is not serial correlated, the lagged values of q itself should be valid instruments. However, the assumption is rejected by the Sargan test of overidentifying restrictions. This suggest that there is serial correlation in the error term. The result is consistent with either assumption that there are serial correlated adjustment cost shocks or with an autoregressive measurement error. Then they add the quadratic term of q into the investment regression. According to the authors, the significant non-linear impact of q to investment is consistent with a model of non-convex adjustment costs. So the strong assumption of convex adjustment cost is not necessary. In addition, they use semi-log approximation method and suggest that adjustment costs are very low.

2.2.3 Investment and Euler equation model

The Euler equation model

Although most of the researchers notice that marginal q is unobservable and difficult to measure, and Q model may also involve some endogenous problems, it is still a very popular dynamic model. The reason may be that the Q model is very convenient to estimate. In basic Q model, investment is only determined by q. However, Bond et al. (2004) suggest that it has several implications which should be taken seriously when estimating the Q model. The most important one is that Q should be an endogenous variable in the econometrics model. Besides, in view of both the assumptions require to measure marginal q, using either the average q ratio or an auxiliary econometric forecasting model, measurement error is still significant. Therefore, if the true value of the explanatory variable is $Q*$, and the measured value $Q = Q * + m_{i,t}$, where $m_{i,t}$ is measurement error. Again, mismeasured Q will be correlated with $m_{i,t}$.

As discussed above, better measurement of marginal q is an important way to solve the problems of the Q model. Alternatively. one can also avoid using marginal q.

The Model is also derived through maximising firm's value with convex adjustment cost assumption. The first step is to eliminate shadow value of capital (λ_t) by substituting first order condition for investment, the λ_t in Equation (2.5) into Equation (2.6). The expression could be given as,

$$-\left(\frac{\partial \Pi_t}{\partial I_t}\right) = \left(\frac{\partial \Pi_t}{\partial K_t}\right) - (1-\delta)\beta_{t+1} E\left[\frac{\partial \Pi_{t+1}}{\partial I_{t+1}}\right] \tag{2.17}$$

Use the net revenue function in Equation (2.1). When the assumption of perfectly competitive markets holds. The equation above could be altered to

$$\left(\frac{\partial G}{\partial I_t}\right) = E_t\left[\psi_{t+1}\right] + \left(\frac{\partial F}{\partial K_t} - \frac{\partial G}{\partial K_t} - \frac{r_t}{p_t}\right), \tag{2.18}$$

where $\psi_{t+1} = \left(\frac{1-\delta}{1+p_{t+1}}\right)\frac{p_{t+1}}{p_t}$ is a real discount factor and $\frac{r_t}{p_t}$ is the user cost of capital. Using the adjustment cost function, the Euler equation model is,

$$\left(\frac{I}{K}\right)_t = a\left(1 - E[\psi_{t+1}]\right) + E\left[\psi_{t+1}\left(\frac{I}{K}\right)_{t+1}\right] + \frac{1}{b}\left[\left(\frac{\partial F}{\partial K_t}\right) - \left(\frac{\partial G}{\partial K_t}\right) - \left(\frac{r}{p}\right)_t\right]. \tag{2.19}$$

The standard model implies that investment could be estimated with the expected investment one period ahead. The one-step ahead value can be replaced by the real value in t+1. That is, investment is assumed to be forecasted rationally by firms. As such, the forecast errors are orthogonal to the expected value. So, the Euler equation model shows its advantage in solving endogeneity.

Discussion and evidence

In the market with financial frictions, the neoclassical theory suggests that a financially constrained firm will behave as if it has high and variable discount rate. Whited (1992) finds two implications from this idea. First, financial variables should enter directly into the Euler equation through the Lagrange multiplier. Second, the investment Euler equation of the standard neoclassical model should hold across adjacent periods for unconstrained firms but violate for constrained firms. The standard Euler equation does not take this into account. In comparison with the standard model, several changes are made. First, they maximised the market value with the after-tax dividends but not the net revenue. One advantage of this method is that dividends cannot be negative. This means there could be another restriction, $d_{i,t} \geq 0$. Secondly, Whited (1992) add the variable of debt into the constraint function. Besides, the debt variable is restricted by a transversality condition, which prevents the firm from borrowing an infinite amount to pay out as dividends.

In a frictional market, Whited (1992) measures firms financial constraints by restricting on the availability of debt. A firm cannot get as much debt as in frictionless market. Restrictions could be used to form a new Euler equation. The empirical results, by testing 1024 US manufacturing firms on the annual tape of COMPUSTAT and 338 firms on OTC tape from 1975 to 1986.

They firstly test how financial constraints affect a firm's allocation of investment expenditure. They estimated the Lagrange multiplier [4]. They find that the values of Lagrange multiplier are mostly significant. The result suggests that the Lagrange multiplier are reasonable in the Euler equation framework under financial constraints. They also suggest that effects of financial variables in an augmented version of the Euler equation are significant for the financially unhealthy firms but not for those in good financial health. The standard Euler equation model fits well only for the uncon-

[4] The Lagrange multiplier is the shadow value of capital, as we introduced above.

strained firms, while the augmented Euler equation (with debt constraints) improves the performance when estimating constrained firms.

Bond and Meghir (1994) also consider the Euler equations with the hierarchy of finance. Similarly, Bond and Meghir (1994) augment Euler equation with debt. In addition, they introduce two sources of discrimination between retained earnings and new share issues into the model. The authors document that the firm's financial policy may play an important role in investment decisions. If a firm has zero dividends and zero new shares issued, then it is likely to be constrained. Then a short windfall of internal funds will increase investment. Bond and Meghir also augment the Euler equation model with debt which will affect a firm's financial policies through the taxes and bankruptcy costs.

Hubbard et al. (1995) also use the Euler equation due to the mismeasurement of marginal q. They also consider the problem of the standard Euler equation that it does not fit all the firms well. They find that sample splits based on firm size or maturity do not produce distinctions. In their paper, they also mention that 'the failure of neoclassical investment models to explain firm-level investment behaviour is due to the assumption of frictionless capital markets.' They reject the standard neoclassical model for 'financially constrained firms'.

Following the previous works, Love (2003) empirically tests firm's investment behaviour with the Euler equation model. The author intended to test to what extent financial frictions effect investment. With the constraint that dividend payout should not be less than zero, the first order condition to the maximisation changes to,

$$1 + \left(\frac{\partial G}{\partial I}\right)_t = \beta_t E_t \left\{ \Theta_t \left[\left(\frac{\partial \Pi_{t+1}}{\partial K_{t+1}} \right) + (1-\delta) \left(1 + \left(\frac{\partial G}{\partial I} \right)_{t+1} \right) \right] \right\} \tag{2.20}$$

They suggest that a firm is indifferent to invest today or tomorrow.

Whited and Wu (2006) do not stop improving the performance of the Euler equation model. They said that the tradition in q literature has been to specify adjustment costs that are linearly homogeneous in investment and capital so that marginal q will equal average q. The quadratic adjustment cost, denoted as $G(I_{i,t}, K_{i,t})$ is the legacy of q model to Euler equation model. They adhere to the constant of linear homogeneity but allow for non-linearity in the marginal adjustment cost function. They change the adjustment costs into,

$$G(I_{i,t}, K_{i,t}) = \left(a + \sum_{m=2}^{M} \frac{a_m}{m} \left(\frac{I_{i,t}}{K_{i,t}} \right)^m \right) K_{it} \tag{2.21}$$

,where a_m, m and M, are parameters to be estimated, and M is a truncation parameter that sets the highest power of $I_{i,t}/K_{i,t}$.

2.3 Investment and cash flow sensitivities, evidence and discussions

As we mention above, the neoclassical investment models do not take financial market imperfection into consideration. Investment cash flow sensitivity is a popular proxy of financing constraints. The idea is that if a firm is financially constrained, its investment relies on its internal finance or cash flows. However, there are also many papers which find that there is not such a monotonic relationship financing constraints and the sensitivity.

2.3.1 Financing constraints and investment-cash flow sensitivities

When the capital market is not perfect, there should be a 'lemon premium'. In Fazzari et al. (1988b), marginal q value of good firms can be denoted as q^G and bad firms q^L. If the percentage of good firms is p, the weighted average value should be $\bar{q} = pq^G + (1-p)q^L$, and the break even q value of a dollar of new investment finance by stock is given by $q = q^G/\bar{q} = 1 + \Omega$. The Ω is the lemon premium.Then, the first order condition of a firm's maximum value which incorporate lemon premium indicates that firms will choose to issue shares only when marginal q on an additional project exceeds $1 + \Omega_t(1 - leverage_t)$, where $leverage_t$ is the maximum leverage ratio. The model intends to show that firms cannot fund the project if they exhaust internal funds and project's marginal q is not high enough. To test the theory, they use a panel from 1970 to 1984 and 421 manufacturing firms. They divide the sample with a single criterion, dividend payment. The implication is that firms with lower dividend-income ratio retain most of their earnings and they are more likely to face financial constraints. Fazzari et al. (1988b) apply Q model and the empirical results show that investment of financially constrained firms rely more on cash flow. In another word, a firm with high investment-cash flow sensitivity may imply that it is financially constrained.

2.3.2 Discussion and extension

There are many papers which question the results of Fazzari et al. (1988a). According to Cooper and Ejarque (2003): 'there are reasons to be cautious about this conclusion as there is no model with borrowing constraints which supports the inference drawn form the Q-theory based empirical results'. For example, as mentioned above, the mismeasurement of marginal q. (Erickson and Whited, 2000; Gomes, 2001). Cooper and Ejarque (2003) estimate a class of dynamic optimization models, and they find that market power plays a key role of linking the investment with internal funds. The link still exist even though financial markets are perfect.

Kaplan and Zingales (1997) apply a static model. They assume that firms face a cost premium for external funds, $C(B, r_w)$, which is convex in the amount of external finance (B) [5] and r_w is the wedge between internal cost and external cost. They maximise firm value under this assumption, and they find that investment is positive related to internal funds.

They then use a sample of 49 low-dividend payment firms from 1970 to 1984 which is close as in Fazzari et al. (1988b) The empirical results are very different from the previous work. They found that investment-cash flow sensitivity is higher for not constrained firms and lower for constrained ones. The possible explanation of this non-monotonicity result is that external finance is very expensive so that unconstrained firms rely more on internal finance.

Fazzari et al. (2000) then suggest that the main problem of the model in Kaplan and Zingales (1997) is that their model assumes that the second order derivative of external financing costs and borrowing ($\frac{\partial^2 C}{\partial B^2}$) is identical for constrained and unconstrained firms. Fazzari et al. (2000) said that the constrained firms should have a larger $\frac{\partial^2 C}{\partial B^2}$. Empirically, the sample selected by Kaplan and Zingales (1997) are relatively homogeneous for purposes of testing for capital market imperfections. It is difficult to classify these firms by degree of financing constraints.

Bond et al. (2003) empirically examine how financial variables affect firm investment

[5] $\frac{\partial C}{\partial B} > 0$, and $\frac{\partial^2 C}{\partial B^2} > 0$.

behaviour in four countries in Europe. They hypothesize that different financial systems have different impacts on investment through the channel of financial constraints, given the fact that UK and US have market-based financial systems, whereas Japan and Germany have bank-based ones. They estimate two types of investment equations, the Euler equation model and the error correction model (ECM). The reason that they use two models is to find whether the results are robust as these two models are derived by different methods. In addition, these two models are not mutually exclusive, and no signal model is more preferable than the other. The data they use for these four countries range from 1978 to 1989. The UK sample consists of 571 firms quoted on the London Stock Exchange. The French and Belgian 21 samples comprise 1,365 firms and 361 firms respectively and the data are collected by INSEE and bank of Belgium. The German sample comprises 228 firms quoted AG corporations. They test the error-correction model with first difference GMM and Within Groups and the Euler equation model is tested with GMM. Bond et al. (2003) said that the GMM method is preferable because the explanatory variables are likely to be endogenous. GMM method could control the bias due to unobserved firm- specific effects and endogenous variables. The empirical result shows that investment of firms in UK is more constraint to internal finance. Two models are consistent with each other. This finding is said to be consistent with that market oriented financial systems perform less in channelling funds to constrained firms with good investment opportunities. The result also implies that UK firms have higher investment-cash flow sensitivity. Investment cash flow sensitivities are also affected significantly by the country-specific effect.

Brown et al. (2009) studied the sensitivity by casting focus on a fact that investment cash flow sensitivity is declining over time. This is also found in Allayannis and Mozumdar (2004)[6]. Brown et al. (2009) firstly explain several potential causes of this phenomenon. There are some predictions that present good ideas and perspectives for further study. The first reason is the changing composition of investment. The authors suggest that there are two types of investment, R&D and physical. Most studies only examine physical investment, while the composition of R&D investment is increasing. Second, capital market improvement will decrease the sensitivities. This is because firms can get more external funds and thus firms are less constrained than before.

[6] Allayannis and Mozumdar (2004) found that investment cash flow sensitivities for constrained and unconstrained firms are 0.585 and 0.213 in the period 1977-1986 but the sensitivity decline to 0.196 and 0.175 respectively from 1987-1996.

Thirdly, firms with negative cash flows are more likely to be young firms which made the heaviest use of equity finance. Failure to include stock in the regression may overstate the decline of the sensitivity. Finally, they said, R&D investment rely more on equity finance while physical investment relies on debt because of the collateral value. They test their predictions by augmenting the Q model. They add two variables, net new funds from stock issues and net new long term debt, to control the source of external finance. The data are publicly traded manufacturing firms from 1970 to 2006. They divide the sample into three sub-periods: 1970-1981, 1982-1993, and 1994-2006 and 1849, 1969 and 2383 firms examined in different periods. The model is tested with the first-difference GMM method. The result shows that R&D investment is increasing but physical investment decreasing over time. Physical investment cash flow sensitivity decreases sharply (about 60% from 1970 to 2006). For R&D investment, cash flow coefficients did not decrease. In addition, R&D investment cash flow sensitivity increases sharply without external funds from equity. The result shows that an improvement in the equity market will decrease R&D cash flow sensitivity. This study implies that external finance is an important variable, which will improve the Q model.

Guariglia (2008) suggests that 'internal' and 'external' financing constraints have different impacts on cash cash flow sensitivity. They use a panel of 24,184 UK firms over the period 1993-2003, using firm's cash flow and coverage ratios as measures of 'internal financing constraints' and size and age as proxies of 'external financing constraints'. They find a U-shaped investment cash flow sensitivity. The sensitivity is large when firms are externally constrained but not internally constrained.

Almeida and Campello (2007) analyse investment cash flow sensitivity by using credit multiplier which is identical with collateral effect studied by Hennessy et al. (2007). The multiplier means that firms with higher asset tangibility are more likely to be externally financed. This is because creditors could capture more values when the borrowers default. They explain this relationship by introducing a model. They suggest that financially constrained firms are subject to the constraint of tangibility. That is, the total external funds should be smaller than the tangible assets. In addition their model shows that for constrained firms, investment is positively related to cash flow. The relationship also shows that investment-cash flow sensitivity increase with tangibility. However if tangibility is high enough, investment become insensitive to changes in cash flow. Then, there is no monotonic relationship between investment and cash flow.

They use the data of manufacturing firms over 16 years from 1985-2000 and which total 18,340 firm years. The baseline specification is based on the Q model derived from convex adjustment cost. The difference from the previous studies they add several variables to control cash flow, tangibility and the interaction between cash flow and tangibility. They also introduce two methods to gauge financial constraints, switching regression model and traditional standard regression model. The advantage of using a switching regression model is that it can use multiple variables to predict whether firms are constrained or unconstrained. As tangibility is assumed to endogenously relate to financial constraints, it is preferable to apply this approach. The result shows that the interaction variable has significant impact on investment behaviour. For constrained firms, investment cash flow sensitivity increases in tangibility.

2.4 Investment and uncertainty

2.4.1 Real options

The 'real options theory' is an application of option pricing to economic decisions. The idea is that firms can make their investment decisions as a series of options. Because an investment is irreversible, or partially irreversible, uncertainty will make firms 'wait and see' (Dixit and Pindyck (1994)). More specifically, if there is no uncertainty, firms will invest or disinvest according to marginal product of capital. However, if we take uncertainty into consideration, there will be an inaction zone (Bloom, 2009). The inaction suggests that firms would like to sacrifice the extra returns of a project to increase 'certainty' by waiting (Bernanke, 1983; Brennan and Schwartz, 1985; McDonald and Siegel, 1986). The right of 'choosing investment time' is a key difference between market friction models and 'real options models'(Boyle and Guthrie, 2003; Strebulaev and Whited, 2011). More specifically, the financial market frictions, such as asymmetric information [7] or agency problems [8] may prevent firms investing in profitable projects. This is called 'now-or-never' investment. It is different from 'wait and see'.

[7] For example Greenwald et al. (1984); Myers and Majluf (1984)

[8] see Stulz (1990)

Uncertainty and adjustment costs

Investment adjustment costs are necessary when studying 'real options'. In other words, if there is no adjustment cost, firms do not need to 'wait' and the value of 'real options' will be zero. In the Euler equation and Q model, a firm's fixed capital investment is subject to 'quadratic adjustment cost'. The quadratic adjustment cost is increasing convexly in the level of investment and divestment. However, this model has not performed well (Cooper and Haltiwanger, 2006). Whited (1998) suggests that the failure of the Euler equation model is because the model only uses convex adjustment cost. Bond and Van Reenen (2007) said that the assumption of strictly convex adjustment costs was introduced primarily for analytical convenience, but its poor performances motivate researchers to find alternative approaches. There are several key features of data that suspect the effectiveness of convex adjustment costs: Infrequent and lumpy adjustment of capital; high correlation between investment and profit; and the low serial correlation of investment (Cooper and Haltiwanger, 2006).

Then, many papers argue that non-convex adjustment costs play a more important role. Abel and Eberly (1994) suggest that because of non-convex adjustment costs and uncertainty, there will be three investment regimes, positive investment, negative investment and inaction. Abel and Eberly (1999) suggests that uncertainty and irreversibility prevent firms form selling fixed capital when marginal capital productivity is low. As the result in the long run, firms will accumulate less capital.

In terms of fixed adjustment costs, high uncertainty and fixed costs will expand the inaction zone of: investment, hiring, and R&D investment (Bloom et al., 2007; Bloom, 2009). There are two types of fixed costs. The fixed cost proportional to operating profit (Abel and Eberly, 1994; Bloom, 2009) or proportional to capital stock (Cooper and Haltiwanger, 2006; Riddick and Whited, 2009).

The adjustment costs estimated by Cooper and Haltiwanger (2006) are very high. They are roughly 50% of the value of investment. Bloom et al. (2007) set irreversibility of capital to be 50%. Riddick and Whited (2009) apply only quadratic and fixed adjustment costs which are relatively low, suppose investment rate (I_t/K_t) is 10%, the adjustment cost is roughly 4% of the value of capital.

Discussion and extension

Bloom et al. (2007) find that uncertainty can make firms invest projects cautionarily. They use a dynamic structure model (partial equilibrium). Theoretically, their model made three improvements. First, they enable different types of adjustment costs, namely, quadratic adjustment costs, fixed costs and partial irreversibility. Secondly, they use a time-varying uncertainty. They assume that the volatility of demand (or productivity) follows a AR(1) process. Finally, they aggregate over investment and time. Model is simulated on monthly basis, with 250 production unit.

They use both simulated data and UK company data, a panel of 672 publicly traded UK firms between 1972 and 1991. They find that uncertainty can dramatically decrease investment. First year response to demand shocks for low uncertainty firms (lower quartile of the uncertainty distribution) is twice as large as high uncertainty firms (upper quartile of the uncertainty distribution).

Bloom (2009) built another model based on real option. The paper also uses different types of adjustment costs, time-varying uncertainty and generate investment using aggregation. They also find that high uncertainty causes firms inaction. Productivity then will decrease because of the inaction. However, in the median term [9] there will be a recovery of output, and productivity.

Boyle and Guthrie (2003) extend the 'real options theory' with future financing constraints. They analyze the investment timing decision of a financially constrained firms. They find that potential financing constraints in future encourages firms to invest more than their first best level. The reason is because the cash shortfall in future reduce the value of 'real option' and forces firms to exercise these options early. They also evaluate the relationship between investment and uncertainty. Their finding suggests that uncertainty can affect investment through two different channels. The first channel is that uncertainty will increase the value of 'real options'. Firms would like to 'wait and see'. However, the second channel suggest that uncertainty will increase the likelihood of cash flow shortfalls in future. Firms would like to increase current investment. Two channels have opposite impacts on investment. They suggests that in the short term, there is no significant relationship between investment and uncertainty.

Bloom (2014) suggests that real options theory is not valid unless three conditions are satisfied. Firstly, the decisions are not easily reversible. The real options value will be zero if projects are perfectly reversible. Second, real options value also depends on the costs of waiting. If a firm needs to invest in a project immediately, waiting is too

[9] In the model he suggests that the median term is 4 months.

costly. Then, the real options are not as valuable. Finally, actions taken today do not influence the returns of future. If the choice of investment this period will have no effect on the profitability of investment next period, the value of waiting will be zero again.

Sarkar (2000) suggests that based on real options theory, the negative investment uncertainty relationship may not always be right. They find that the relationship between probability of investment and uncertainty is an inverse U curve. The limitation of the model as he suggests in the paper is that it is based on a single-project partial-equilibrium model. In addition the model is not taking financing constraints into consideration.

There are a large amounts of literature which discusses 'real options' in other areas of economics and finance. For example, consumers usually delay their expenditures when they plan to purchase durables (Eberly, 1994), and they are less sensitive to demand and price signals (Foote et al., 2000; Bertola et al., 2005). High uncertainty can reduce investment, hiring and productivity (Bloom et al., 2012). Real options are also used to search the equilibrium rent on leasing contracts (Grenadier, 1995), the dynamics of mergers and acquisitions in oligopolistic industries (Hackbarth and Miao, 2012).

2.4.2 Ambiguity aversion

In macroeconomics, uncertainty can change business cycles though the anticipated change in risk. Under the rational expectation assumption, agents can think rationally, which means agents can analyse information as econometrician. An increase in risk implies higher variance of shocks and larger likelihood of disasters. However, ambiguity is different from risk. Risk suggests that all the agents know the probabilities of different outcomes, but ambiguity means that agents do not know odds (Knight, 1921). Ellsberg (1961) found that there is a behavioural distinction between risk and ambiguity. People prefer to know the odds. There is a simple example, many people prefer to bet on an urn if the number of black and white balls' number is known rather than unknown. Gilboa and Schmeidler (1989) suggests that a decision maker has multiple priors. Every prior is assessed with its minimal expected utility. The minimum of utility is taken over all priors.

Preference

Schmeidler (1989) introduce the non-additive probability, which is also named as capacities. It suggests that agents bet f with limited information. The outcomes are f_1 and f_2 which are mutually exclusive. v is any assignment of the events {neither f_1 nor f_2 occur}, {f_1 occur}, {f_2 occur},{f_1 or f_2 or both occurs}. Given the events, (i) $v(f_1) \geq 0$, $v(f_2) \geq 0$ and $v(1) + v(2) \leq 1$; (ii) v(neither f_1 nor f_2 occurs)=1; (iii) v (f_1 or f_2 or both occurs)=1.

Gilboa and Schmeidler (1989) further extend this model. The difference between ambiguity and ambiguity aversion according to Gilboa and Schmeidler (1989) is the difference between taste (ambiguity aversion) and belief (ambiguity). There are also many papers which extend Bayesian theory with the ambiguity aversion theories by studying how new information updates preferences. Epstein and Breton (1993), suggests that ambiguity aversion contradicts subjective expected utilities (contrary between Ellsberg Paradox and Savage model). The problem is that ambiguity cannot be captured by a single prior. However, as suggested by Epstein and Breton (1993), Bayesian prior exists if most choice problems are sequential and the new information could be updated.

Epstein and Schneider (2001) extend Gilboa and Schmeidler(1989).They build a model of intertemporal utility with ambiguity aversion. They find that prior-by-prior Bayesian updating is the updating rule for such sets of priors. Intuitively, agents are learning. Anderson et al. (2000) distinguishe robustness and learning. Robustness decision makers accept misspecification of the model. They are not using data to improve his model specifications.

The interaction between preference updating and ambiguity aversion is very complicated and there is no consensus. Papers such as Maccheroni et al. (2006),Hanany and Klibanoff (2007, 2008); Ghirardato et al. (2007); Siniscalchi (2011) also discusse the updating rules.

Application of ambiguity aversion

Ambiguity aversion is widely applied in asset pricing literature. Dow and da Costa Werlang (1992) use an example to link asset prices with ambiguity with a non-additive probability measure. A risky assets value could be high, H or low, L. A unit of this asset price is p The capacities are ν^H and ν^L respectively. Under ambiguity aversion,

$\nu^H + \nu^L < 1$. According to the max-min framework, the expected gain from buying a unit of the risky asset is $\nu^H H + (1-\nu^H)L - p$. An agent will only buy the asset when $\nu^H H + (1-\nu^H)L \geq p$. It is the same for selling an asset. The expected minimum return from selling a short position of the asset is $p - (1-\nu^L)H - L$. Therefore, an agent will not sell the assets when the price is high than $(1-\nu^L)H - L$. Finally, if the price is in the support $(\nu^H H + (1-\nu^H)L, (1-\nu^L)H - L)$, an agent will neither buy nor sell. This can be used to understand the 'market freeze' phenomenon.

Anderson et al. (2000) apply the robustness decision theory in asset pricing. They argue that agents are averse to uncertainty because they cannot detect the transition law. They will choose to make robustness decisions to hedge against modelling errors. As a result, the robustness decision makers will add an uncertainty premium into equilibrium security prices.

Chen and Epstein (2002) found two puzzles cannot be explained by risk. They applied ambiguity aversion in asset pricing. The problem is that risk-based models have been found to be insufficient to explain equity premium puzzles in empirical literature. Another problem is called 'home-bias' puzzle. Investment in many countries invest little foreign securities. The results indicate that ambiguity is at least as important as risk when investors making investment decisions. They depose asset excess return into risk and ambiguity.

'Confidence shock' is another channel of explaining how uncertainty affects economic growth. It suggests that consumers have pessimistic beliefs. To our best knowledge, there are few papers which discuss this issue in the area of corporate finance. So we will review the literature to find what we already know. Hansen et al. (1999) introduce two different decision makers, robust decision makers and expected utility maximizers. The difference between two types of decision makers is that robustness decision makers are concern about specification errors, and they want to be insensitive to them when making decisions.

Easley and O'Hara (2009) address a close issue of portfolio choice issue. They suggest that agents' beliefs of the risky asset values are a set of distributions. Denote value of asset i is $v^i \in \{v^i_{\min}, ...v^i_{\min}\}$. If the price falls in to the intervals $[v^i_{\min}, v^i_{\min}]$, agents will have no demand of this risky asset because of ambiguity aversion.

Epstein and Schneider (2010) introduce optimal portfolio choice under ambiguity with max-min method. In a simple 2-period model, an agent have W_1 wealth and the utility is determined by consumption at day 1 and day 2. There is an asset which pays interests at risk free rate r^f plus excess returns r. $\mathcal{P}_1$ is a set of beliefs. The agent chooses consumption C_1 at day 1 and a vector of portfolio shares θ. Then the agent make decision of day 1 consumption and portfolio shares to solve

$$\max_{C_1,\theta_1} \min_{p\in\mathcal{P}_1} \{u(C_1) + \beta E^p[u(C_2)]\} \tag{2.22}$$

Where C_2 is consumption at day 2, which is

$$C_2 = (W_1 - C_1)R_2^w$$

R_2^w is the return of portfolio. The return is determined by risk free rate and excess return.

$$R_2^w = (\exp(r^f) + \sum_{i=1}^{n} \theta_i \exp(r_i))$$

Then we can calculate the share of portfolio under worst case return distribution for that portfolio.

Epstein and Schneider (2010) also introduce the application of ambiguity aversion in asset pricing. They suggest that in a 2-period model, an agent's wealth includes labour income and dividend payment. Labour income grows at a constant rate. The logarithm of dividend growth rate is Δd with variance σ_d^2 and an ambiguous mean $\mu_d \in [\overline{\mu}_d - \overline{x}, \overline{\mu}_d + \overline{x}]$. Then we can calculate the average premium, which consists of risk premium and ambiguity premium. The risk premium is the covariance of consumption growth and stock returns and the ambiguity premium is $\overline{x}$ if $\overline{\mu}$ equals to the true dividend growth rate.

Ilut and Schneider (2014) suggest that agents have a set of beliefs about an exogenous shocks. For example, the belief of an innovation to productivity lies in an interval of means centered around zero. They propose a method to capture 'confident shocks' by measuring the width of the interval. More specifically, a loss of confidence means that the 'worst case mean' becomes worse and the width of interval will be larger. In the model they suggest that the interval follows an AR(1) process. Empirically, Malmendier and Tate (2005) suggest that some CEOs are optimistic (overconfident). They will invest more than first-best level when they have enough internal funds.

2.4.3 Other uncertainty theories

The increase of uncertainty will increase the probability of default as well. As the result, the risk premia will be higher. The increase of borrowing cost will decrease investment.Gilchrist et al. (2014) argue that idiosyncratic uncertainty can change the credit spreads. Besides 'real options' and capital adjustment frictions, distortion in financial markets is another channel that uncertainty can affect the real economy.

On a micro-level, Gilchrist et al. (2014) use credit spreads as an indicator of financial frictions[10]. The results show that firms invest less when uncertainty is high. However, once the level of credit spreads is controlled, firm's fixed capital investment is highly sensitive to credit spreads but less sensitive to uncertainty.

Arellano et al. (2012) also combine financial frictions with idiosyncratic shocks. Hiring inputs is very risky when there are financial frictions and high idiosyncratic shocks. The reason is because of the separation between the time of production and the revenues from their sales. When the financial markets is frictional, firms have limited ways to hedge the risk. The result is that the probability of default will increase, and firms will reduce their hiring of inputs.

2.4.4 Empirical measurements of uncertainty

Uncertainty can take many forms, for example, future prices and wages, productivity and demand, taxes and policies and so on. There is not a unified method of measuring firm-level uncertainty. So here we want to review how to measure uncertainty with firm level data.

Leahy and Whited (1996) suggest that uncertainty is a forward looking variable which relates to the differential between expectations and actual outcomes. Thus, they propose an ex-ante measure rather than ex-post. One solution is to extract information from option prices, but the data are not available. Another method is to use a Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model to estimate a forecast of volatility.

[10]According to Gilchrist et al. (2014), 'Level of credit spreads provides a useful metric for gauging the tightness of financial conditions in the economy ... considerable empirical evidence showing that corporate bond credit spreads form the most informative and reliable class of financial indicators for future economic activity (Gertler and Lown, 1999; Gilchrist et al., 2009)'

Guiso and Parigi (1999) measure uncertainty of Italian firms using two datasets: the Survey of Investment in Manufacturing and the Company Accounts Data Service. The Survey of Investment in Manufacturing dataset reports managers' expectations of future demand. The data not only reports the means of expectations but also the distributions of expected future demand. Then, they can measure uncertainty with the variance of the growth rate of demand [11].

Bo and Lensin (2005) also use the high-frequency data to derive the uncertainty. However, they use a Threshold ARCH (TARCH) model (Glosten et al., 1993) instead of GARCH model. The reason for this is because the volatility of stock market returns is asymmetric. More specifically, a downward movement is often followed by higher volatility than an upward movement.

Bloom et al. (2007) measure uncertainty following the method of Leahy and Whited (1996). They use the standard deviation of daily stock returns as a proxy of uncertainty. A potential problem of this method is that the stock price contains bubbles. They address the problem by normalizing the firm's share return with the FTSE All Share Index. They also consider using standard deviation of the monthly stock returns. They suggest that this can reduce the impact of high-frequency noise.

Gilchrist et al. (2014) measure idiosyncratic uncertainty using high-frequency stock market data [12] of U.S. non-financial companies with at least 1250 trading days. They estimate uncertainty with two-steps. They firstly remove the forecastable variation in daily excess returns using a standard factor model. The excess return is the differential between daily stock return and the risk-free rate. They employ a 4-factor model, which is an augmented Fama and French (1992) 3-factor model with the momentum risk factor Carhart (1997). The second step is calculating the quarterly firm-specific standard deviation of daily idiosyncratic returns which is the OLS residual from 4-factor model.

Han and Qiu (2007) measure uncertainty with quarterly data. They define the uncertainty with cash flow volatility which is the variation of operating cash flow scaled by the absolute value of the mean over past 4 years (16 quarters).

Caglayan et al. (2012) suggest a method to measure uncertainty for unlisted firms. For unlisted firms, we do not have high frequency data. To address this problem, they estimate an AR(1) model for sales augmented with time dummies and industry specific

[11] They define the demand growth as changes in the quantity demanded while holding the price constant

[12] Center for Research in Security Prices (CRSP) data base.

dummies. The uncertainty will be the 3-year moving standard deviation of unpredicted residuals. We will also introduce this method in the following chapters.

2.5 Corporate liquidity management

Research on firm cash holding is becoming more popular after the financial crisis of 2008-2009. Cash was a major determinant of firm survival during the crisis (Almeida et al., 2013). There are two basic questions: why do firms hold cash and what is the optimal cash holding level? Keynes answers the first question in 1936. He argues that liquidity management is important because of financial constraints. If there is no friction in financial markets, firms' financial decisions would be irrelevant.

2.5.1 Precautionary savings: a theory

A general idea of precautionary savings is the trade-off between marginal benefit and cost. We present a model of cash holdings based on Almeida et al. (2004), which formalizes Keynes' intuition. When firms anticipate financing constraints in the future, they tend to hold cash today. It is costly to hold cash because higher cash savings reduces current valuable investment. So, firms need to balance their present and future investment.

The model has three periods, 0, 1 and 2. A firm has an option to invest in a long-term project at time 0, I_0 and pays off $F(I_0)$ at time 2. It can also invest I_1 at time 1 and pays off $G(I_1)$. At time 2, firms can liquidate the assets I_0 and I_1, with the price p^l, where $p^l \leq 1$ and I_0, $I_1 \geq 0$ The cash flow is denoted as c . They assume that the discount factor is 1, and every one is risk neutral. At time 1, firm existing assets can produce a cash flow, cf_1. With probability p, the time 1 cash flow is high, which is cf_1^H and with $(1-p)$, cash flow is low, which is cf_1^L. Cash holdings is denoted as c.

The firm's objective is to maximise the sum of dividends:

$$
\begin{aligned}
&\max(d_0 + pd_1^H + (1-p)d_1^L + pd_2^H + (1-p)d_2^L)\\
&\quad d_0 = cf_0 + B_0 - I_0 - c \geq 0\\
&\quad d_1^s = cf_1^S + h^S + B_1^s - I_1^s + c \geq 0, \quad \text{for} \quad S = H, L\\
&\quad d_2^s = F(I_0) + G(I_1^S) + p^l(I_0 + I_1^S) - B_0 - B_1^S, \quad \text{for} \quad S = H, L\\
&\quad B_0 \leq p^l I_0\\
&\quad B_1^S \leq p^l I_1, \quad \text{for} \quad S = H, L\\
&\quad ph^H + (1-p)h^L = 0
\end{aligned}
\tag{2.23}
$$

In the equation, B_0 and B_1 are the borrowing amounts, which is constrained by the collateral value of investment. S is the state, which could be high or low. Firms can also use futures to hedge cash flow. They will pay h^H if cash flow is high or get h^L if cash flow is low and $h^H = -(1-p)/p * h^L$

Define $f(I_0) = F(I_0) + p^l I_0$, and $g(I_1^S) = G(I_1) + p^l I_1^S$. If the firm is not financially constraint, it can invest at the first best levels. We can write the first order conditions as:

$$
f'(I_0^{FB}) = 1
$$

$$
g'(I_1^{FB,S}) = 1 \quad \text{for} \quad S = H, L
$$

For financially constrained firms, they will not invest at their first best level. So, the investments under financial constraints at time 0 and 1 are I_0^* and I_1^*. They are smaller than first best investment levels. They will exhaust borrowings and pay zero dividend. The Maximization problem can be rewritten as:

$$
\max \left\{ f\left(\frac{cf_0 - c}{1-p^l}\right) + pg\left(\frac{cf_1^H - \frac{1-p}{p}h^L + c}{1-p^l}\right) + (1-p)g\left(\frac{cf_1^L - h^L + c}{1-p^l}\right) \right\} \tag{2.24}
$$

Firms can use hedging to eliminate its cash flow risk. The optimal amount of hedging is given by $h^L = p(cf_1^H - cf_1^L)$. The optimal cash holdings c^* is determined by the first order condition (partial derivative of function 2.24 with respect of c):

$$
f'_c\left(\frac{cf_0 - c*}{1-p^l}\right) = g'_c\left(\frac{E(cf_1) - c^*}{1-p^l}\right) \tag{2.25}
$$

We could get optimal cash holdings c^* which is a function of cf_0. If we calculate the partial derivatives of both sides of Equation (2.25) with respect of cf_0, we will get the cash flow sensitivity of cash:

$$\frac{\partial c^*}{\partial cf_0} = \frac{f''_{c,cf_0}(I_0^*)}{f''_{c,cf_0}(I_0^*) + g''_{c,cf_0}(I_1^*)} \tag{2.26}$$

Almeida et al. (2004) assume that function $f(.)$ and $g(.)$ have homogeneous properties. So, the sensitivity is positive. In brief, the model suggests that optimal cash level is a function of cash flow $c^*(cf_0)$, and its derivative is positive.

2.5.2 Precautionary savings: evidence and discussion

Given the theory above, Almeida et al. (2004) assume that managers can use financial derivatives to hedge income shortfalls and define the financing constraint problem with whether or not a firm can invest at first best level. They empirically test their theoretical results. They use the dataset of US companies and 5 classification criteria of financing constraints, which are dividend payouts, asset size, the existence of a bond rating, the existence of a commercial paper rating, and the KZ index[13]. They find a positive cash-cash flow sensitivity. The sensitivity will be higher if a firm is more financially constrained.

Denis and Sibilkov (2009) document that cash holdings are more valuable for constrained firms. Because of costly external finance, constrained firms hold more cash when they want to invest big projects. Higher cash flow enable the firm to undertake profitable projects. They also empirically find that constrained firms hold low free cash flows. So many constrained firms hold low cash reserves.

Sufi (2009) studies cash holdings and market frictions from the perspective of credit lines. Credit lines are an instrument of liquidity management and a substitute of cash reserves. More specifically, lines of credit are a form of committed credit from banks, which overcomes frictions by ensuring that funds are available for valuable projects. The goal of the paper is to find the difference between lines of credit and cash. The data set they use is U.S. non-financial firms from 1996 to 2003, 31,533 firm-year observations. Sufi (2009) classify financial constraints with cash flow sensitivity of cash. They find that 'increasing lagged cash flow by 2 standard deviations at the mean increases the likelihood of obtaining a line of credit by one-quarter standard deviation. Firms rely highly on cash when they have low cash flow.

Campello et al. (2010) survey 1,050 Chief Financial Officers (CFOs) in the U.S., Europe, and Asia after financial crisis. They report that financially constrained firms

[13] The index measured in Kaplan and Zingales (1997).

cut 15% cash stocks but financially unconstrained firms only cut 2%. This is strong evidence which shows that financial constraints can significantly affect liquidity management behaviours.

The concept of precautionary savings is very broad. Firms hold cash not only because of financing constraints. Bolton et al. (2011) argue that liquidity management is a key component of dynamic risk management. The paper find that cash holdings and lines of credit play different roles. High cash holdings will increase the sensitivity of investment to 'marginal q'. They also suggest that firm value is sensitive to both idiosyncratic and systematic risk. The systematic shocks can be hedged with financial derivatives. To limit the value exposure to idiosyncratic risk, firms can manage their cash reserves by adjustment of investment and divestment. As q result firms with high idiosyncratic risk hold more cash. Palazzo (2012) also find that risk can affect a firm's optimal cash holding policy. Theoretically, they assume that shareholders value future cash flows using a stochastic discount factor, which is determined by aggregate risk. They define aggregate risk as the correlation between cash flows and aggregate shock[14]. The riskier firms (with higher correlation) need to hold more cash because they are more likely to experience a cash flow shortfall.

Holding cash is not the only way to hedge income shortfall. Firms can reduce current debt, and they can borrow more when cash flow is low. However, Acharya et al. (2007) show that cash stocks and debt capacity are not equivalent when there is uncertainty about future cash flows. This is because financially constrained firms are not likely to get external finance during bad times. They use US COMPUSTAT data from 1971 to 2001. The empirical results find that unconstrained firms do not save cash out of cash flows. They use free cash flows to reduce the amount of debt. The behaviour of constrained firms is totally different. They are more likely to save cash out of cash flows.

We can find similar findings in Han and Qiu (2007). They build a two-period investment model to show that firms save cash to balance current and future investment. When future cash flow risk cannot be fully diversified, constrained firms will hold more

[14]In Palazzo (2012), the stochastic discount factor at time t is $e^m = e^{-r-(1/2)\sigma_z^2-\sigma_z \epsilon z,t+1}$. e^{-r} is risk-free interest rate. $\epsilon z, 1\ N(0,1)$ is the aggregate shock at time 1. The pay-off of the risky asset is $e^z = e^{\mu--(1/2)\sigma_x^2+\sigma_x \epsilon x,1}$. $\epsilon x, 1\ N(0,1)$ is the idiosyncratic shock. Assume $COV(\epsilon z, 1, \epsilon x, 1) = \sigma_{x,z}$. We will have $COV(m_1, x_1) = -\sigma_z \sigma_x \sigma_{x,z} = \beta_{x,m}$. $\beta_{x,m}$ is the systematic risk of the cash flow. As $\beta_{x,m}$ increases, the cash flow becomes more correlated with aggregate shock and hence less valuable.

cash. They also test this with US data from 1997 to 2002. The finding is that constrained firms will save more cash if cash flow volatility is high. However, unconstrained firms show no systematic relationship between cash holdings and the volatility. The finding is consistent with Riddick and Whited (2009) as introduced above. That is, income uncertainty/volatility is the key of precautionary cash holdings. Boyle and Guthrie (2003) find a link between liquidity management and 'real options'. They document that the value of 'real options' will decrease if a firms is likely to be financial constrained in future. Holding more cash will not only solve the financial constrained problem, but also make 'waiting' less risky.

2.5.3 Cash holdings and agency problems

Since 1986, Jensen proposes that managers prefer retaining cash to increasing payout. However, agency problems may not be significant, as U.S. share holders can force managers to return excess funds to them (La Porta et al., 2000). Shareholders under poor protection will face more severe agency problems.

Dittmar et al. (2003) shed light on corporate governance and cash holdings. They expand the trade-off theory by identifying two costs of holding cash and cash equivalents. If there is no agency problem, managers need to maximise shareholder's benefits. The cost is the opportunity cost of holding cash compared with other investments with at the same risk level. The cost of holding cash will increase if mangers have the opportunity to engage in wasteful capital spending and acquisitions. They use a panel of 11,000 companies from 45 countries. Therefore, this enables them to test the evidence of agency problems across countries. They find that, after controlling for industry effects, firms in countries where shareholder protection is low hold almost 25% more cash than firms in good protection countries. The difference increases to 70% after they control for capital market development.

Dittmar and Mahrt-Smith (2007) investigate the relationship between cash holdings and corporate governance. The measure the value effects of governance on cash resources to find whether or not a firm holds excess cash. If a manager manage liquidity inefficiently, shareholders will undervalue the cash holdings. They use US publicly traded firms from 1990 to 2003, which consists of 1,952 firms and 13,095 observations. They employ two measures of corporate governance: the degree of managerial entrenchment due to takeover defenses and the presence of large shareholder monitoring. They find that \$1.00 of cash in a poorly governed firm is valued at \$0.42 to \$0.88, but it will be doubled in well governed firms.

Nikolov and Whited (2014) specify three types of agency problems: limited managerial ownership of the firm, compensation based on firm size, and managerial perquisite consumption. Managers have strong incentives to hide misbehaviour. To solve this problem, they use a dynamic structure model and simulated method of moments to find the links between agency problems and cash holdings. They employ Compustat and ExecuComp data. The panel has 1,438 firms from 1992 to 2008 with 9,274 observations. They find that managerial resource diversion has a strong positive effect on cash accumulation.The managers can obtain benifit from resource diversion. Low managerial ownership is a key that firms accumulate more cash.

There are also many papers which find that the link between agency problem and cash holdings is weak. Mikkelson and Partch (2003) use a sample of 89 publicly traded U.S. firms that hold high cash and cash equivalents (more than 25%) from 1986-1991. They find that many firms hold high cash reserves temporarily. They also find that operating performance of holders of large amounts of cash is greater than the performance of firms that had transitory large holdings of cash. Governance characteristics are not related to cash holdings. In addition, high cash holdings can improve a firm's performance, for example, faster growth rate, higher investment and R&D expenditure, and higher market-to-book values of assets.

Bates et al. (2009) also question the principle-agent conflicts which can increase cash holdings. They find the fact that firms with low cash and high Tobin's q hold more cash. They apply three methods to find the link between agency problems and cash. They firstly test the correlation between cash flow and GIM index of, an 'often-used proxy for managerial entrenchment'. Secondly, they find whether cash becomes less valuable as cash holdings increase with the close method used in Dittmar and Mahrt-Smith (2007). If cash becomes less valuable, it means firms hold excess cash. Finally, they estimate the relationship between excess cash and the future growth in cash balances. As the result, they find that agency problems cannot explain why firms hold so much cash.

2.6 Financial markets, firm investment and cash holdings in China

Chinese firms have been growing very fast over the last decades. The average firm-level asset growth rate in China is 8.6% from 2000-2007 (Guariglia et al., 2011). In the previous sections we review investment and liquidity management of firms. In this section we want to review the papers to answer three questions: why firms invest so much? How did they finance their projects? How did they manage their cash holdings?

2.6.1 Institutional background of China

The China's malfunctioning financial market is related to political and social issues. Li et al. (2008) suggests that policy affiliation can have positive effect on firm's performance and private sector is discriminated in China. The reason can be found in the history of People's republic of China. After 1949, the Communist Party won the civil war. China started the socialist transformation. Private firms are transformed to SOEs which were owned by public. After that private firms were diminished from China until early 1980s. In 1980s, private business was allowed but the size of private business is limited.

Private business grew rapidly after Deng Xiaoping's Southern Tour in 1992. In 2004, private sector grew from nothing to providing nearly 50% of total employment and 60% of the industrial output (Li et al., 2008). The size of private sector is still expanding now. Private sector exceeds state sector from both size and productivity. Although private sector has been growing fast in last decades, private firms still suffer from policy and social discrimination.

In addition, private firms need to deal with unfavorable economic environment as most resources are still controlled by the government and SOEs are more likely to get bank loans. Gregory et al. (2000) report that even in the late of 1990s, the private sector received less than 1% of the total loans from commercial banks. Brandt and Li (2003) summarize four possible reasons of discrimination. Firstly, banks are mostly state-owned, so they may have a 'purely ideological preference for lending to government-owned firms over private firms'. Secondly, banks have closer relationship with SOEs, so they can obtain their credit information easily. Thirdly, some private firms are more likely to be discriminated in other markets. According to the authors, if a certain group is discriminated against in either the input or product markets, banks may not provide loans to these firms as the likelihood of default will be higher. Finally, private firms are riskier than SOEs. The government will always bail SOEs out in the event of default. When private firms encounter negative shocks, they may not repay the loans.

Although discrimination still exists today, the Party put its effort to create a fair market which enables private firms compete with firms with other ownerships.

In recent years, positive steps taken to reduce the overall level of financing constraints. Borst and Lardy (2015) suggest that the financial system in China is now transforming from 'a traditional bank-dominated and state-directed financial system toward a more complex, market-based system'. Since 2013, policymakers in China started to reform the financial system in China. There are several main reforms. First, establish private financial institutions. These banks have no shares held by Government. They should be responsible for their own risk. The private institutions can prove a buffer against possible financial contagion from failing institutions Second, develop capital markets. The aim of this reform is to create a registration-based stock issuing markets, which allows more small firm get direct finance. However, according to the authors, although access to capital markets for private firms has been improving in recent years, private firms get the small share of financing compared to their contributions [15]. In addition, there are many other reforms such as improving interest rate liberalization, moving towards market based exchange rate, promoting capital account convertibility [16], establishing a deposit insurance scheme, creation of a market-based exit mechanism and experiment with mixed ownership reform [17].

Lardy (2014) discusses several channels that private firms can get financial resources. Firstly, he suggests that retained earnings are important for Chinese private firms. From 2000 to 2008, 71% of investment on average is financed by returned earning and 56% in the period 2009-2011 [18]. As private firm's productivity is much higher

[15]SOEs own 70 percent of the market capitalization of listed A-share firms.

[16]Chinese authorities want to achieve full convertibility of the Renminbi since 1993. However, by the end of 2013, the share of Chinese financial assets available for purchase by foreigners is extremely small

[17]This reform has mainly been implemented by non-financial companies. SOEs can sell a proportional of shares to private shareholders.

[18]The number is calculated with National Bureau of Statistics (2013c) and ISI emerging markets, CEIC database.

than SOEs [19], there is an advantage for private firms to retain earnings.

One important reason that private firms in China are usually thought to be financially constrained is because they are less likely to get bank loans. Lardy (2014) documents that 'banks everywhere are extremely reluctant to extend credit to small setup family owned firms with little or no collateral.' However, Lardy also points out that the growth of credit to individual and private business is very rapid. The loans to private sector grows by more than 25% annually from 2002 to 2012.

Lardy (2014) also mentions that there is a significant improvement in equity financing. In 2009, China opened a new board at Shenzhen stock exchange, called ChiNext. The board targets faster growth, higher innovative firms and lowers capital requirement. From 2010 to 2013, private firms raised 660 billion RMB from stock markets in China, while SOEs only raised 166 billion. Beside the formal financing channels, micro-finance is another financing channel which has increased the flow of credit to private firm. By the end of 2012, there are more than 6,000 micro-finance companies, issued 592 billion RMB loans, which is 8 times the amount 3 years earlier.

2.6.2 An introduction of China's financial system

As reviewed above, financial market frictions can significantly affect firm's optimal investment decisions. Allen et al. (2005) document that the financial system in China is malfunctioned. Th fey provide evidence in terms of both financial markets and banking system.

Firstly, there are two domestic exchanges in China, SHSE (Shanghai Stock Exchange) and SZSE (Shenzhen Stock Exchange). Although they have been growing fast, they are not efficient. The share prices are distorted, and fail to reflect fundamental values. The evidence is that in China, the stocks of large companies are not frequently traded comparing with other major stock markets. However, the stocks of relatively small and medium companies are traded extremely frequently[20].

Morck et al. (2000) suggest a consistent finding with Allen et al. (2005), that stock markets are not efficient. They suggests that in emerging countries, includ-

[19] OECD documents that in 1998-2003, productivity of private firms on average is more than twice that of SOEs

[20] Chinese large listed companies are less frequently traded than the large companies of developed markets, but stocks of small firms are more frequently traded than technology companies on NASDAQ.

ing China, stock prices are more synchronous. They explain this with two reasons reasons. First, emerging economies often provide poor and uncertain protection of private property rights. Political events and rumors in such countries could, by themselves, cause market-wide stock price swings. Second, less protection of shareholders' property rights against corporate insiders can reduce the capitalization of firm specific information into stock prices.

Secondly, China's financial markets scale is relatively small. The external funds raised by Chinese stock markets in 2002 are only 16% of GNP which is much less than the average level 40% found in La Porta et al. (1997). Finally, the venture capital in China is less developed. The size of this industry is small and the venture companies are inefficient and poorly regulated (Bruton and Ahlstrom, 2003)

The Banking sector according to Allen et al. (2005) is large but inefficient. First, they are owned by the government, and the four largest are state-owned banks. Second, the size of nonperforming loans is very large. A large proportion of nonperforming loans is caused by political or non-economic purposes.

Wang et al. (2009) suggest that firm investment does not significantly respond to market performance in China. Stock price reveals little information of fundamentals and unexpected earnings. The result suggests that the stock market in China is also less efficient. There are three possible reasons. First, many listed firms are owned by government, and they are not traded freely. Second, the listed firms have poor profitability and corporate governance. Third, market manipulation is severe, and the legal system is weak.

A more recent review of the Chinese financial system provided by Allen et al. (2012) suggest that China's financial system has progressed considerably in the last few years. Many non-state-owned and foreign banks enter the banking sector and enhance the efficiency of the banking system and non-performing loans over GDP has been decreasing. Financial markets have been growing fast and play a more important role. However, there are still many problem left behind. State-owned banks are still controlling the banking system. There are several potential crises for banks in China. First, high non-performing loans and a drop of banks' profits may cause banking sector crisis. Second, the bubbles in the real estate market may burst.

Megginson et al. (2014) document that in 2012, banks still dominate China's financial system. The size of bank loans is over $10.01 trillion US dollars which is 8.4 times of corporate bonds and 2.7 times of stock market size.

Chow and Fung (1998) empirically study investment cash flow sensitivity in the manufacturing sector of Shanghai. They use a sample of 5325 manufacturing enterprises in Shanghai from 1989 to 1992. They find that, in Shanghai, the investment-cash flow sensitivity is positive. Private firms show the highest investment-cash flow sensitivity. However, the collective-owned firms are less sensitive to cash flow. They suggest that there is an inter-firm loan channel of re-allocating financial resources between state owned and collective owned firms.

Small firms will less collateral are believed to be more financially constrained than large firms. However, Chow and Fung (2000) use the same dataset as Chow and Fung (1998), and find that small firms are less financially constrained. They suggest three possible explanations for the surprising result. First, small firms are more profitable. They can finance themselves with internal finance. Second, large and state owned firms have heavy indebtedness. As the result they do not have sufficient cash to invest. Third, small firms can get informal finance, which can alleviate financial constraints.

Héricourt and Poncet (2009) discuss how foreign direct investment (FDI) alleviate financial constraints in China. They estimated the Euler equation model and augmented Euler equation model with debt constraint. Using firm-level data with 1,300 Chinese firms from 2000-2002, they find that private firms are more financially constrained than SOEs. However, the financing constraints of private firms soften if they can get abundant foreign investment.

Poncet et al. (2010) conduct a more throughout study on financial constraint problems in China. They also estimated the augmented Euler equation model consistent with Héricourt and Poncet (2009). They use Chinese firm-level data from the data set contains more than 20,000 Chinese firms over the period 1998–2005. In addition to the finding that private firms are mode financially constrained, they suggests that the presence of foreign firms in China improve the functioning of capital markets for private Chinese firms. This is because the investment-cash flow sensitivity is softened by abundant amount of foreign investment. However, the financing constraint problem can be reinforced when the presence of state-owned firms is strong.

Lin and Bo (2012) argue that in the sample of listed firms, firms either with the state as the largest shareholder or with a higher state share do not face less financial constraints. They use a sample contains 1325 non-financial firms listed on either the

Shanghai or Shenzhen Stock Exchanges, from 1999 to 2008. They find that state ownership can either increase or no decrease the investment-cash flow sensitivity. In addition, state ownership can increase KZ index, which suggests that firms with high state ownership are more financially constrained.

Bo et al. (2014) provide a systematic analysis of how the investment of Chinese listed firms respond to the financial crisis. They use quarterly data of 1689 listed non-financial firms, from 2006Q1 to 2010Q3. They listed three differences between Chinese and mature market economies, namely financial system, regulation of financial system and international trade. They suggest three possible channels that financial crisis can affect Chinese firm-level investment, namely financing constraint, uncertainty and demand. They find that the negative demand shock plays a more important role. During the crisis, investors prefer to invest financial assets rather than fixed capital and non-state firms suffer more from negative effect of the financing crisis.

2.6.3 Financing channels and investment efficiency in China

Financing channels in China

The links between financial development and growth are generally positive. Yet, China is a counterexample. Chinese economic growth is very fast especially the private sector. Then the questions of why they grow so fast and how they finance themselves given the inefficient banking system and financial markets arise (Allen et al., 2005).

Allen et al. (2005) study three sectors, state sector (includes state owned enterprises (SOEs)); listed sector (includes listed firms); and private sector (includes all the private and local government owned firms). They suggest that bank loans and self fund raising are the two most important financing channels. The reason that private firms in China grow faster than other economies is that alternative financing channels exists. These channels are informal. The funds are from friends, families or other private credit agencies. A firm's reputation and relationships will play an important role.

Ge and Qiu (2007) suggest that trade credit can help to solve mis-allocation of bank loans. Private firms in China are more likely to use trade credit to invest projects than transaction purposes. This is consistent with Allen et al. (2005) [21]

[21] Based on the survey conducted by Allen et al. (2005) , 60% of private firm managers point out that trade credit is the financing channel.

Cull et al. (2009) find that trade credit is more likely to be redistributed from SOEs to more constrained firms. Especially for the private firms with good performance, they can extend trade credit. However, in China, the allocation of formal credit improved over time and they do not find strong evidence that trade credit played an economically significant role. The magnitude of the trade credit is small relative to the size of the formal financial sector.

Guariglia et al. (2011) use a very large dataset including 79,841 unlisted firms in China from 2000 to 2007. They find that SOEs as well as collective firms' asset growth [22] are not sensitive to cash flow, but private and foreign firms are very sensitive. Firms with high growth and cash flow sensitivity grow faster and display higher productivity than the low sensitivity firms. Thus, they conclude that private firms are financially constrained but they are productive and profitable. They can use internal finance to support their growth.

Ding et al. (2013) suggest that firms with high working capital investment-cash flow sensitivities but low fixed capital investment cash flow sensitivities are more financially constrained. They have higher working capital and investment opportunities. These firms can use working capital to alleviate financing constraints.

Investment efficiency in China

As mentioned above, in China, the financial system is controlled by banking sector, and banking sector is largely owned by the government. Government intervention then can easily lead firm's investment decisions. Faccio et al. (2006) suggest that it is not unusual that firms are close to governments around the world and close politically connections can improve firm performance and enhance firm value. However, Fan et al. (2007) use a sample of 790 newly partially privatized firms. They find that firms without political connected CEOs perform better than those with politically connected CEOs. There are three facts support this argument. First, they find that firms with political connected CEOs have relatively lower three-year post-IPO stock return. Secondly, the first-day stock return is also lower if the CEOs are politically connected. Third, the politically connected CEOs are more likely to appoint other bureaucrats to the directing board rather than professional managers.

There are many papers which argue that the state sector is the least efficient but

[22] Collective firms are owned by communities and managed by local governments.

also least financially constrained. Bai et al. (2006) suggest that SOEs, because of the political and social stability requirements and economic objectives, can get a large amount of bank loans given despite their poor performance. The same argument can also be found in Chen et al. (2011). They suggest that one possible reason that SOEs under-perform is because they help to accomplish 'social and political goals', such as social stability, public welfare, regional development, etc.

Dollar and Wei (2007) apply survey data which cover 12,400 firms from 2002-2004. They conclude that SOEs should reduce their capital stock rather than increase. Capital stocks in China are misallocated. Mis-allocation problem also exit in terms of bank loans. (Allen et al., 2005) suggest that SOEs raise 25% bank loans more than their financial needs.

Chen et al. (2011) use a sample of Chinese listed non-financial firms with 7,658 firms during 2001 to 2006. They use the lagged value of Tobin's q as the proxy of investment opportunity. They find that the investment-investment opportunity sensitivity of SOEs is significantly lower than non-SOEs. Also they find that political affiliation can significantly decrease investment efficiency.

Greenaway et al. (2014) examine the relationship between foreign ownership and their performance using a panel of 21,582 firms over 2000-2005. The result suggests that the relationship exhibits an inverted U shape. When foreign share is low, increasing foreign capital can increase firm's performance, while when foreign share is high, increasing foreign capital can be detrimental to firm's performance.

Guariglia and Yang (2016b) analyse Chinese listed firms from 1998 to 2014. Their interest in focusing on free cash flow. They find strong evidence that many firms in China invest inefficiently. The inefficiency is caused by financing constraints and agency problems. They firstly predict the optimal investment value with lagged information according the the method suggested by Richardson (2006). Then they can determine whether or not the firm is over or under-invested. They find that financing constraints make under-investing firms more sensitive to free cash flow, while over-investing are more sensitive to free cash flow when agency problems are high.

2.6.4 Firm cash holdings in China

There is only a few papers which study cash holdings in China. According to the precautionary saving theory, cash accumulation behaviour is interpreted as a method to solve financing constrained problems. Megginson et al. (2014) use a panel of China's share-issue privatized firms from 2000 to 2012 and they find that cash holding and state ownership are negatively related. Also the cash holdings will increase when the share of institutions decrease. The reason is because state shares and institutional shares make firms more likely to get loans in a bank-based system. They also find that marginal value of cash declines as state ownership rises.

Lian et al. (2012) support the dynamic trade-off theory of Opler et al. (1999) in cash holdings. They use the Chinese listed firms over the period 1998 to 2006. The sample consists of 1,026 firms with 7,383 firm-year observations . They find that there is a target level of cash holdings. Above this target the cash holdings adjustment speeds are higher than below the target. Adjustment of cash holdings is faster when the firm is large and the distance of current cash holdings to current cash holdings is large. They also find that debt financing has limited effect on cash adjustment.

Chen et al. (2012) focus on the relationship between the split share structure reform and listed firms cash holdings. The reform commences in 2005 in China. During the period, large shareholders of the firms need to convert non-tradable shares into tradable. After the reform, large shareholders and managers are concerned more about share prices. They use a panel of 1,293 listed firms from 2000-2008. They observe a decrease of cash holdings after the reform. Also, the cash-cash flow sensitivity declines as well. Corporations with poorer governance decline more. These findings suggest that the reform removes some agency problems. Managers hold less excess cash and this can alleviate financing constraint problems. They also find that the decline of cash in SOEs is higher than private firms. This suggest that the agency problems are more severe in SOEs.

Alles et al. (2012) use a panel of 780 Chinese listed firms and 7310 observations between 1998 and 2009. Their study suggests that in China, the adjustment speeds of cash holdings towards target levels are comparable to those in developed economies. The finding is contrary to presupposition that investor protection in China is weaker than developed countries (Allen et al., 2005) and it will reduce firms' ability of cash adjustment.

Feng and Johansson (2014) focus on the effects of political participation and cash holdings in China. They use a panel of 2,115 firms over 1999-2009. They suggest that political extraction, bureaucrats and politicians extracting rent from firms, has an adverse effect on cash holdings. However, private entrepreneurs can alleviate that risk by increasing political participation.

Guariglia and Yang (2016a) use a panel of 1478 Chinese listed firms over the period 1998–2010. They suggest that listed firms in China tend to manage cash holdings actively. The cash holdings behaviour of Chinese listed firms is mean-reverting, and there is a target level of cash reserves. They also find that the speed of adjustment (SOA) of cash holdings towards target level in China is slower than western countries[23]. This may be because of high adjustment costs of cash holdings in China. In terms of adjustment costs of cash holdings, firms with excess cash display higher adjustment speeds than their counterparts with a cash deficit. Finally, they find that institutional settings have no significant impact on adjustment speeds [24].

[23] According to the authors, 'it takes the typical Chinese firm between 1.2 and 2.1 years to complete half of its required cash adjustment.'

[24] They control institutional settings in this paper with ownership structure, regional development, and proximity to a stock market.

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Chapter 3

Investment and Investment Opportunities: Do Constrained Firms Value Investment Opportunities More in China?

3.1 Introduction

Financial constraints are usually considered when studying firm level investment behaviour. It is believed that financial constraints are obstacles to investment. Many try to interpret investment and financial constraints from the perspective of cash flow. Fazzari, Hubbard, and Petersen (1988) find that the financially constrained firms (i.e. firms with lower dividend payout ratios) display a higher sensitivity of investment to cash flow than unconstrained firms (i.e. firms with higher dividend payout ratios). However, when we study China's firms, and apply only the conventional idea– financial constraints and investment-cash flow sensitivities– seems insufficient. The reasons are twofold. First, q could be mismeasured. Many empirical studies use the financial accelerator model when studying firm-level investment. It is believed that investment is affected by 'fundamentals' and 'financial factors' jointly. Marginal q and cash flow are used as proxies for 'fundamentals' and 'financial factors' respectively. However, the mis-measurement of q is an unsolved problem. Many use cash flows as a proxy of financial factors. Yet, in fact, cash flows may contain information about investment opportunity. This could erode the importance of 'fundamentals'. If the fundamentals cannot be measured properly, Gilchrist and Himmelberg (1999) doubt that financial factors could overstate their effect. Bond et al. (2004) were also concerned by this. They argue that cash flow may then provide additional information when average q variable is poorly captured. Second, investment-cash flow sensitivity cannot explain why constrained firms invest more and grow faster than unconstrained. Recent studies shows that in the context of China, private firms which are more likely to be constrained, invest more and grow faster than unconstrained firms. Moreover, their growth is a main factor of China's fast growth (Allen et al., 2005). If financial constraints cannot constrain investment, it is hard to interpret investment-cash flow sensitivity even though we find a monotonic relationship.

Considering the two problems above, our study will focus on two research questions. First, how do firms in China respond to investment opportunities? Second, why do private firms which are more financially constrained invest more and grow faster than state owned enterprises (SOEs)? We attempt to find the answer from the relationship between investment and investment opportunities. An investment opportunity is a key factor when firms make investment decisions. Besides, studying investment and investment opportunities could avoid the debate of investment cash flow sensitivity.

Allen et al. (2005) study this topic from the perspective of financial markets. They use the data set from 'China Security Regulation Committee' to show that the financial system is underdeveloped in China. They state that stock markets in China are smaller than most of developed countries and China's banking system is much more important in terms of size. Its ratio of total bank credit to GDP is 1.11 which is higher than in Germany. However, when studying private firms only, this ratio drops sharply to 0.24. This suggests that private firms are externally financially constrained. However, despite the almost nonexistence of formal mechanisms, the private sector relies more on alternative mechanisms. Reputation and relationships play an important role in China, as firms in China can borrow through informal channels.

Allen et al. (2012) define the alternative mechanisms more specifically. They document that alternative and informal channels are important, which includes funds from family and friends and loans from private (unofficial) credit agencies. The alternative channels also include illegal channels, such as smuggling, bribery, insider trading and speculations during early stages of the development of financial markets and real estate market, and other underground or unofficial business.

Guariglia et al. (2011) find that private firms in China growing at a very fast rate is due to their abundant cash flow and high productivity. Hence, they do not need well developed financial markets. Combining the two ideas above together, they find that in China, financial constraints are not a big obstacle.

Savings policy is one way of relieving external financial constraints. Ding et al. (2013) on the other hand, find that working capital management could also help firms to alleviate the effects of financial constraints.

The papers above suggest that the financial constraint problems could be relieved and that cash flow is not the only way of internal finance. Although firms could alleviate financial constraints with different policies or be funded from different channels, firms will invest only when an investment opportunity is good enough.

In this chapter, we want to address the two research questions above. We will study the firm level investment from both theoretical and empirical perspectives. We will follow the Q model and better measure investment opportunities. Theoretically, we measure investment opportunities from different perspectives, with the aim of providing a more comprehensive and precise measurement of investment opportunities. We will decompose the Q model based on its definition, and measure q from both supply and demand side. After we decompose q, we find that q is subject to both demand shocks and supply shocks.

Empirically, we measure investment opportunities from the supply side with total factor productivity (TFP hereafter) growth and use sales growth as a proxy for demand shocks. We combine TFP and sales growth to measure investment opportunity. We also forecast q with panel VAR suggested by Gilchrist and Himmelberg (1995). This method allows us to take forward looking investment opportunities into consideration.

In order to take a deep look at how different investment opportunities affect firm-level investment and how different types of firms response to investment opportunities, we apply an impulse response function and system Generalised Method of Moments (GMM) estimation on our data set. The data set used comes from the annul survey conducts by National Bureau of Statistics (NBS) of China. The panel contains more than 600,000 firms from 1998 to 2007.

Using the data above we find that private firms show higher sensitivity to investment opportunities than SOEs with all three different proxies of investment opportunities. This suggest that private firms value investment opportunities more. This result provides a new explanation as to why private firms grow faster than SOEs. In addition, we find that firms in China show different responses to different opportunity shocks. For example, foreign firms show high sensitivity to demand growth but relatively low sensitivity to TFP growth. Also, we find that cash flow could significantly affect investment sensitivity to growth. However, we find a weaker impact of cash flow on investment-TFP growth sensitivity. This suggests that cash flow contains more information of demand shocks than supply shocks. This again shows that demand shocks and supply shocks contain different information. Thus, decomposing investment opportunities to demand and supply side is necessary.

There are two main contributions of our study. First we explain why private firms invest more from the perspective of investment opportunities. This puzzle has been explained by internal finance (Guariglia et al., 2011), good working capital management (Ding et al., 2013), social capital and social network[1] (Du et al., 2015), and partnership with foreign companies (Greenaway et al., 2014). In this chapter, we explain the puzzle from the fundamental side. Investment of private firms are more sensitive to

[1]Firms can build social capital by entertaining and gift giving. This can help them to get more short-term debt.

fundamentals. They value investment opportunities more and more efficiently invest according to investment opportunities. Second, we suggest a new direction of measuring q. In addition, there are some small contributions. Few studies use Panel VAR and impulse response function to study firm level investment in China, and few apply fundamental q to measure investment opportunities of Chinese firms.

The rest of this chapter is organised as follows. Section 2 describes how we decompose Q model and how we combine supply and demand side together. Section 3 discusses our baseline specification and empirical methodology. Section 4 introduces the data we use and also presents some summary statistics. Section 5 reports our main empirical results and finally section 6 is our conclusion.

3.2 Theoretical framework: measuring q from demand and supply sides

To prove our hypothesis that financially constrained firms care more about investment opportunities, we need to better capture investment opportunity. In our sample most of the firms are unlisted, so we do not have Tobin's q. There are many influential papers which use an adjusted Q model but few when they are studying China's firms.

When calculating total profit, we need to think about two perspectives: demand and supply. Cooper and Haltiwanger (2006) assume that current profits for given capital can be denoted as $\Pi(A, K) = AK^{\theta}$, where A is productivity shock and K is capital. The higher the productivity, the lower the cost will be and the profit of each unit of product will be higher. It is obvious that net income is decided by supply and demand side together.

The basic Q model could be expressed as:

$$\left(\frac{I}{K}\right)_t = a + \frac{1}{b}\left[\left(\frac{V_t}{(1-\delta)p_t^K K_{t-1}}\right)\frac{p_t^k}{p_t}\right] + \tau_t + e_t \tag{3.1}$$

where

I_t is fixed investment at time t,

K_t is tangible fixed assets,

V_t is firms' value at time t,

δ is depreciation rate,

p_t^K is investment price and p_t is the price of output,

τ_t is stochastic technology shocks,

e_t is an idiosyncratic component.

Besides, a firm's value is always assumed as the sum of discounted net revenue in future, which could be written as,

$$\widehat{V}_{i,t} = E_t \left[\Pi_{i,t} + \beta_{t+1}\Pi_{i,t+1} + \cdots \beta_{t+s}\Pi_{i,t+s} + \beta_{t+s+1}\widetilde{\Pi}_{i,t+s+1} \right] \tag{3.2}$$

The net revenue function comprises two components, which are operating profit π_t and total costs of fixed capital investment C_t.

$$\begin{cases} \pi_t = p_t F\left(K_t : \tau_t\right) \\ C_t = G(I_t, K_t : \tau_t) + p_t^I I_t \end{cases} \tag{3.3}$$

Then, the equation could be simplified to

$$\frac{\Pi_t}{C_t} = \frac{\pi_t}{C_t} - 1 \tag{3.4}$$

$\frac{\Pi_t}{C_t}$ could be interpreted as the rate of return comparing with total input and $\frac{\pi_t}{C_t}$ as the productivity of the investment. Therefore,

$$\Delta\left(\frac{\Pi}{C}\right)_t = \Delta\left(\frac{\pi}{C}\right)_t. \tag{3.5}$$

$\Delta\left(\frac{\pi}{C}\right)_t$ is the increase of a firm's revenue. Then, its increase rate is $(\Delta\frac{\pi_t}{C_t}/\frac{\pi_t}{C_t})$.

We could approximate the increase rate as

$$\Delta\left(\frac{\pi}{C}\right)_t / \left(\frac{\pi}{C}\right)_{t-1} \approx \ln\left(\frac{\pi}{C}\right)_t - \ln\left(\frac{\pi}{C}\right)_{t-1} = \ln\frac{\pi_t}{\pi_{t-1}} - \ln\frac{C_t}{C_{t-1}}$$

Following Abel and Eberly (1999), given predetermined capital stock, productivity, and demand, a firm can choose the the optimal input of labor, and Riddick and Whited (2009) document that variable factors are costlessly adjustable. So we denote the opporating profits as

$$\pi_t = Z_t K_t^{1-\gamma}. \tag{3.6}$$

where Z is a combination of demand and productivity shock (Riddick and Whited, 2009; Bloom et al., 2007). Foster et al. (2008) and Wu (2014) suggest a linear combination

$$Z_t = X_t(A_t)^{\varepsilon-1} \tag{3.7}$$

where X_t is demand and A_t is productivity and ε is demand elasticity over price and it is assumed to be greater than one.

Then, the revenue growth rate could be decomposed as

$$\Delta\left(\frac{\pi}{C}\right)_t / \left(\frac{\pi}{C}\right)_{t-1} = \ln\frac{Z_t}{Z_{t-1}} + (1-\gamma)\ln\frac{K_t}{K_{t-1}} - \ln\frac{C_t}{C_{t-1}} \tag{3.8}$$

$\ln\frac{K_t}{K_{t-1}}$ reveals the increase of capital input. In addition, $\ln\frac{C_{i,t}}{C_{i,t-1}}$ shows the growth of total cost, which should be positively related to the increase of input. Note that it is very hard to measure the adjustment costs, which are components of total costs. In order to simplify Equation (3.8), we assume that the increase of labor and capital input could offset the increase of total costs but their differences ($\theta_{i,t}$) are firm specific and time specific.

$$\theta_{i,t} = (1-\gamma)\ln\frac{K_t}{K_{t-1}} - \ln\frac{C_{i,t}}{C_{i,t-1}} \tag{3.9}$$

Equation (3.8) could be simplified as,

$$\Delta\left(\frac{\pi}{C}\right)_{i,t} / \left(\frac{\pi}{C}\right)_{i,t-1} = \ln\frac{Z_t}{Z_{t-1}} + \theta_{i,t}. \tag{3.10}$$

The equation above shows that a revenue increase is monotonically related to the technology improvement.However, a firm's revenue function from the supply side does not reveal the demand side of the market. If we take inventory into consideration, especially for a manufacturing firm, its output should be different from its sales, $F\left(L_t, K_t : \tau_t\right) \neq sales$.

As discussed above, the growth of investment costs, $\frac{C_{i,t}}{C_{i,t}}$, is difficult to measure and firm specific. This is because c_t contains not only the total input but also adjustment costs or even fixed costs and there is no consensus on whether or not the adjustment cost is convex. We could assume that,

$$\frac{C_{i,t}}{C_{i,t-1}} = 1 + c_{i,t}$$

where $c_{i,t}$ is a firm specific term. Then we use sales (S) as the proxy of opporating revenue, the increase of net profit could be given as

$$\Delta\Pi_{i,t} = \Pi_{i,t} - \Pi_{i,t-1} = (a_{i,t} + \varepsilon x_{i,t} + \theta_{i,t})S_{i,t-1} \times (1 + c_{i,t}) + c_{i,t}\Pi_{i,t-1} \tag{3.11}$$

where, $a_{i,t}$ denotes firm i's technology improvement at time t, and $x_{i,t}$ denotes demand growth comparing with last year at time t.

The equation above interprets that the expected increase of profit is jointly affected by demand growth and productivity growth. We assume that firms could forecast their one-year-ahead net profit, and they form their long term expectations based on one-year-ahead forecasts. At time t, $\Pi_{i,t+1}$could be written as,

$$\Pi_{i,t} = E(\widehat{\Pi_{i,t}}) = \Pi_{t-1} + E(\widehat{\Delta\Pi_{i,t}}) \tag{3.12}$$

where $\widehat{\Pi_{i,t}}$ and $\widehat{\Delta\Pi_{i,t}}$ are estimated value of net profit and increase of net income, and $\Delta\Pi_{i,t} = E(\widehat{\Delta\Pi_{i,t}})$. Then, firm's expected net income growth rate ($\mu_{i,t}$) could be estimated as,

$$\begin{aligned} E(\widehat{\mu_{i,t}}) &= \frac{E(\widehat{\Delta\Pi_{i,t}})}{\Pi_t} && (3.13)\\ &= \frac{\Pi_t - \Pi_{t-1}}{\Pi_t} && (3.14)\\ &= \frac{(a_{i,t} + \varepsilon x_{i,t} + \theta_{i,t})S_{i,t-1} \times (1 + c_{i,t})}{\Pi_{i,t-1}} + c_{i,t}. && (3.15) \end{aligned}$$

Since all the expectations are formed at the end of time t or at the beginning of time $t+1$, we calculate net income after $t+1$ by using $\widehat{\mu_{i,t}}$. The estimated firm value is,

$$\begin{aligned} \widehat{V}_{i,t} &= E_t\left[\Pi_{i,t} + \beta_{t+1}\Pi_{i,t+1} + \cdots \beta_{t+s}\Pi_{i,t+s} + \beta_{t+s+1}\widetilde{\Pi}_{i,t+s+1}\right] && (3.16)\\ &= E\left[\sum_{s=0}^{n} \beta_t^s (1 + \widehat{\mu_{i,t}})^s \Pi_{i,t}\right] && (3.17) \end{aligned}$$

where β represents $\beta(1-\delta)$ a combination of discount factor and depreciation factor. According to Equation (3.1), marginal q is

$$q_t = \frac{V_t}{(1-\delta)p_t^K K_{t-1}},$$

we can forecast marginal q with estimated $\widehat{V}_{i,t}$. The estimated marginal q ($\widehat{q}$) is

$$\begin{aligned} \widehat{q} = E &\left[\sum_{s=1}^{n} \beta_t^s \left(1 + \frac{(a_{i,t} + \varepsilon x_{i,t} + \theta_{i,t}) \times (1 + c_{i,t})S_{i,t-1}}{\Pi_{i,t-1}} + c_{i,t}\right)^s\right] \\ &\times \frac{\Pi_{i,t-1}}{(1-\delta)p_t^K K_{t-1}} \end{aligned} \tag{3.18}$$

This model has some advantages over previous ones: first, it is a better measure of marginal q. Second, we decompose demand growth from demand and supply side.

This is not only because they are captured from supply and demand sides. They also capture long term and short term growth, as productivity shocks will have a long term effect while demand shocks tend to have short term effect. We are going to test how productivity and demand shocks affect firm investment decisions.

3.3 Empirical specifications and estimation methodology

3.3.1 Baseline specification

As predicted in the model (Equation 3.18), the marginal q depends on a linear combination of three components: demand growth ($x_{i,t}$), productivity growth ($a_{i,t}$) and firm specific growth factor ($\theta_{i,t}$). We also take these three components into consideration in our empirical section. There are two research questions pointed out by our theoretical framework. First, what is the difference between investment opportunities. Secondly, how to combine different investment opportunities (from both demand side and supply side) together.

We start from the Q model,

$$I_{it}/K_{it} = a_0 + a_1 q_{it} + a_2 CFK_{it} + v_i + v_t + vj + v_{jt} + e_{it}, \tag{3.19}$$

where q is used to capture investment opportunities and cash flow is used to capture internal finance. a_1 represents how an investment opportunity could affect investment decisions and that is the key point that we are going to study. Although q is widely used and many influential studies adjusted the measurement of it, there is no single method believed as the best.

In our theoretical model, we suggest that there is a linear combination of investment opportunities from both supply and demand sides. Therefore, in the empirical part we want to estimate how different investment opportunities affect investment decisions. What is the difference between them? To precisely link with our theory, the empirical study will discuss investment opportunities measured from three perspectives: supply side (q^S), demand side (q^D) and fundamental q[2].

[2]Fundamental q is more specifically introduced in next section.

We define investment (I) as the purchase of fixed tangible assets. Investment is generated with the book value of tangible fixed assets at time t minus the book value of tangible fixed assets at time $t-1$ plus depreciation at time t. Investment rate (I/K)is given by the ratio of tangible fixed assets to investment.

Cash flow term is included in the regression as it is to control the internal finance, which is important for a financially constrained firm to make investment decisions (Fazzari et al., 1988). Cash flow is defined as the sum of firms' net profit and accumulative depreciation of fixed assets. CFK in equation (3.19) is cash flow divided by the capital stock. As most of firms in NBS dataset are unlisted, Liu and Xiao (2004) question the reliability of NBS data. They find that there is a propensity of profit–disguising in China. Small and private firms tend to disguise more profits. However, despite the mis-reporting error, we find that the cash flow of private firms is higher than other firms on average. The ranking of cash flow to assets ratios should not change. Therefore the measurement error could be assumed as time-invariant (Guariglia, 2011). If the firms disguise a proportion of their profits, they can be removed as fixed effects. We include a cash flow variable in our model because it is believed as an important factor to investment. Since our hypothesis is focusing on investment and investment opportunities, we are not going to discuss whether or not cash flow is a good indicator of financial constraints.

Equation 3.19 comprises five types of error terms: (1) firm specific time invariant effects (v_i); (2) time specific effects (v_t); (3) industry specific effects (v_j); (4) time specific and industry specific effects (v_{jt}), which are used to capture industry specific business cycles. (5) an idiosyncratic error (e_{it}).

In this chapter, and also in chapter 4, we are going to estimate the regressions with system GMM method. In Bond (2002), he argues that dynamic models are popular when estimate Euler equations for household consumption, adjustment cost models for firms' factor demands, and empirical economic growth. The failure of Euler equation model in investment has been discussed by Whited (1998). Therefore, we choose to use q model rather than Euler equations.

Whether or not include lagged dependent variable depends on the models. Since we are estimating q models, including lagged dependent variable is not necessary. This is because of investment are very lumpy, and serial correlation of investment is low

(Gomes, 2001). We also find consistent result with our Chinese data[3]. Therefore, lagged investment may have weak explanatory power. There are some examples of using system/differenced GMM on investment issues without lagged dependent variables[4], for example Bloom et al. (2007).

In our theory, we point out that q is also determined by firm specific factor ($\theta_{i,t}$). Thus we expand our model by including control variables, namely firm size, the asset tangibility ratio, liquidity ratio, and export dummy,

$$\begin{aligned} I_{it}/K_{it} = a_0 + a_1 q_{it} + a_2 CFK_{it} + a_3 tangibility_{it} + a_4 liquidity_{it} \\ + a_5 size_{it} + + a_6 age_{it} + a_7 Expdum_{it} + v_i + v_t + vj + v_{jt} + e_{it}. \end{aligned} \tag{3.20}$$

Firm size is defined as the value of nature logarithm of real total assets. Small firms are more likely to face financial constraints but large firms are assumed to be more diversified and less prone to bankruptcy. *tangibility* is the ratio of tangible assets to total assets. Highly tangible firms are more likely to operate in less dynamic industries with lower growth potential (Hovakimian, 2009). So, we may expect a negative relationship between investment and tangibility. We also take liquidity into consideration. This variable is defined as the difference between a firm's current assets and its current liabilities, normalized by total assets. High liquidity could alleviate financial constraint problems but could be detrimental to profitability (Ding et al., 2013). If high liquidity has a negative impact on profitability, we expect it will have a negative relationship with investment. Firm age is also a proxy to control financial constraint problems. It is usually assumed that older firms are less likely to face asymmetric information problems and less constrained. However, in China, old firms may be less efficient (Ding et al., 2013), so firm age could have negative impact on investment. *Expdum* is a dummy variable which equals 1 if the firm exports in that year. We use an export dummy because exporters are often found to be more productive than non-exporters(Bernard and Jensen, 1999). This argument suggests that exporters have better investment opportunities and export behaviour will have positive impact on investment.

Equation 3.20 also comprises five types of error terms, which are identical with the error terms in 3.19.

[3]The serial correlation of investment over capital is -0.04.

[4]In terms of econometric method. There is indeed non-dynamic setting in system GMM. I would like to instrument independent variables which are not strictly exogenous. In Stata, non-dynamic setting is also allowed by the command 'xtabond2'.

We aim to find how fixed investment responds to invest opportunity shocks. According to most empirical studies (Ding et al., 2013; Chen and Guariglia, 2013), we separate our sample by four different ownerships. State owned enterprises (SOEs, we will introduce firm ownerships later) are expected to be the least financially constrained as they are likely to benefit from soft budget constraints and favoritism from state-owned banks, while private firms are most financially constrained, since banks are reluctant to lend them money .

3.3.2 Measurement of q

Investment opportunities and supply shocks

Since most firms in our dataset are unlisted, we cannot calculate Tobin's q. As introduced in our theoretical framework, we firstly adopt the backward looking approach to find some proxies of q. According to our theoretical framework, we could find that investment opportunity could be measured from both supply and demand side. More specifically, if we exclude firm specific term, firms' profit growth could be decomposed to TFP growth and sales growth. We use TFP growth as the proxy of q to control the investment opportunity from supply side. More importantly, according to Chen and Guariglia (2013), TFP will have a long term impact on firms. We measure TFP based on the method suggested by Levinsohn and Petrin (2003).

Investment opportunities and demand shocks

Another proxy, that is more usually applied to capture investment opportunity, is sales growth. However, it is also criticised as sales could be highly correlated with cash flow. This will affect results of estimation. However, as suggested by Bernanke, Gertler, and Gilchrist (1999) that sales for small firms are more sensitive to business cycles may reflect non-financial factors; and Love and Zicchino (2006) argue that sales are a more exogenous variable to measure investment opportunity since it is determined by demand side. Therefore, we still estimate the equation with sales growth.

Forcasted q/ Fundamental q

Besides the q that we measure from supply and demand, as introduced above, we could measure investment opportunities with a forward looking and dynamic method which is usually called forcasted q or fundamental q. In our estimation we will denote it as FQ [5].

3.3.3 Estimation methodology

We estimate the equations above with two methods. They both have some advantages over the other and we attempt to find some consistency between the results from two difference methods. They will be more specifically introduced as follows.

Panel VAR and impulse response function

Gilchrist and Himmelberg (1999) (GH hereafter) and Love and Zicchino (2006) (LZ hereafter) suggest that investment is determined by the fundamental and financial parts jointly. One significant difference between our work and theirs is that they are using marginal capital productivity (MPK hereafter) and sales to capital ratio to explain how investment respond to investment opportunities, but we are going to study fundamental from both supply and demand side. This is because sales may be highly correlated with cash flow. In addition we suggest that TFP is a preferable proxy when measuring marginal q. To tackle the issues above, we use impulse response function suggested by GH(1998) and LZ(2006). In our dataset, the time period is very short but number of firms is very large. So, we use panel VAR (vector autoregressive).

The impulse response function (IRF) shows the reaction of one variable when the variable is shocked by a one-standard-variance while holding other shocks equal to zero. As is concerned by both GH(1998) and LZ(2006), the actual variance-covariance matrix of errors is unlikely to be diagonal. To isolate shocks to one of the variables in the system, it is necessary to decompose the residuals [6].

LZ(2006) explain that the identifying assumption is that the variable in front is assumed to have contemporaneous and lagged impact on the variable behind, while the variable behind could only have a lagged impact on the variable in front. That

[5] Please find detailed description about how to measure fundamental q in the appendix.

[6] It is known as Choleski decomposition. The decomposition makes residuals become orthogonal. The usual convention is to adopt a particular ordering and allocate any correlation between the residuals of any two elements to the variables that come earlier in the first in the ordering. (Please find more details about IRF and Panel VAR in the appendix.)

is to say, the variables which come earlier in the systems are more exogenous and the ones that appear later are more endogenous.

Both GH(1998) and LZ(2006) use this ordering, but they put the variables in different sequences. GH(1998) suggest that I/K, the ratio of investment to capital, is exogenous and has a contemporaneous impact on MPK and CFK (cash flow scaled by capital), but assume there is no feedback from MPK shocks to I/K, or from cash flow to MPK. However, LZ(2006) assume that MPK is the exogenous variable. They use sales to capital as the proxy for MPK. They argue that the sales to capital ratio depend on the demand, which is outside of the firms' control. Investment is likely to become effective with delay since it requires time to become fully operational.

Although GH(1998) and LZ(2006) have a difference of opinion in ordering, they both agree that MPK is more exogenous than cash flow. We will use the first ordering method to estimate backward looking q and the second estimates forward looking q.

System GMM

We then use the system GMM method to test our baseline specifications. This is because our data has a very large number of N but small T. It takes into account unobserved firm heterogeneity and possible endogeneity and mismeasurement problems of the regressors. By adding the original equation in levels to the system and exploiting these additional moment conditions, Arellano and Bover (1995) and Blundell and Bond (1998) found a dramatic improvement in efficiency and a significant reduction in finite sample bias compared with first-differenced GMM.

Bond et al. (2001) have more specifically discussed first-differenced GMM and system GMM. The first-differenced GMM removes the fixed effects such as firm specific and industry specific effects by taking the first difference of the regression. Then, use lagged regressors as instruments under the assumption that time varying disturbance in the original level equations are not serially correlated. There are several advantages of using this method. First, because the unobserved fixed effects are removed, estimates will no longer be biased by any omitted variables that are constant over time. Second, the use of instrument variables allows the parameters estimated consistently given the regressors can be endogenous. Finally, the use of instruments potentially allows consistent estimation even in the presence of measurement error. However, there is large finite sample biases when instruments are weak. When the time series are persistent and the number of time series observations is small, the first-differenced GMM estimator is poorly behaved. Our dataset also has short time series[7]. System GMM performs better under this situation. According to the authors, the system estimator exploits an assumption about the initial conditions to obtain moment conditions that remain informative even for non-stationary time series. As such, to avoid weak instrument problem, we choose to use GMM method.

In the presence of serial correlation of order n in the differenced residuals, the instrument set needs to be restricted to lags n+1 and longer for the transformed equation and lag n for the level equation (Roodman, 2009). We initially use two lags of all regressors as instruments in the differenced equation. However, since all our models generally fail the test for second-order autocorrelation of the differenced residuals, levels of all regressors lagged three times and longer are used as instruments in the first-differenced equations. First-differenced variables lagged twice are used as additional instruments in the level equations.

The system GMM method is widely used in dynamic models. It is a popular method when estimate the regression which dependent variable follows AR(1) process. For example household consumption, adjustment cost models for firms' factor demands, and empirical economic growth. However, there is indeed non-dynamic setting in the system GMM. There are some examples of using system/differenced GMM without lagged dependent variables: Bond (2002) introduces dynamic panel data models, but when they estimate production function with the system GMM they do not include lagged depended variable into the regression. There are some other examples such as Bond (2002); Bloom et al. (2007); Ding et al. (2013).

3.4 Data and summary statistics

3.4.1 Data

The firm-level data we have come from annual surveys conducted by National Bureau of Statistics (NBS). The data are collected annually on industrial firms which include all of state owned firms and non-state owned firms with sale scale above 5 million RMB (usually called 'above scale' firms), from 1998 to 2007. The industries of these firms are

[7] On average T is less than 4.

mining, manufacturing and public utilities. The original dataset contains more than 600,000 firms and 2,000,000 observations across 31 provinces.

We then check the representativeness of our dataset. Table 3.1 provides an overview of our dataset focusing firms' size. Table 3.2 and Table 3.3 are reported by China Statistical Yearbook (2007) (Statistical Yearbook hereafter) and Brandt et al. (2012). Brandt et al. (2012) made a significant contribution in summarizing NBS dataset. That is why we compare our result with theirs. Information of China Statistical Yearbook is officially published by NBS. Brandt et al. (2012) also used the firm-level 'above scale' NBS data from 1998 to 2006, but not the same version as ours. China Statistical Yearbook (2007) does not provide information of sales at aggregate level.

Comparing table 3.1 with 3.2, we found that the number of observations each year is slightly smaller than that reported by Statistical Yearbook especially in 1998 and 1999. Therefore, it is reasonable that our aggregates could be slightly smaller than Statistical Yearbook. The results show that most of the aggregates from our dataset are either identical or slightly smaller than form Statistical Yearbook. The differences between our data set and China Statistical Yearbook is very small. So we can use our data to explain most of China economy.

From our NBS data, we can find that the number of firms increases from 154,870 in 1998 to 336,696 in 2007. The increasing number shows that more firms were becoming 'above scale' firms in this 10-year period. Especially from 2003 to 2004, the number increases 42.2%. Although all the aggregates are increasing, we find that the total number of employees increases only 41.7% but total profit before tax in 2007 is more than 18 times as large as in 1998 and total sales increases 5.5 times in the 10-year period. Generally speaking, firms' profit and sales grow faster than firms' size (total assets, total number of employees etc.). In other words, firms in China are more profitable than before.[8]

[8]Please find further introduction on NBS data in the appendix.

Table 3.1: Sum of firm size of our NBS dataset

	Number of firms	Total assets (1 trillion)	Sum of employees (10 million persons)	Total equity (1 trillion)	Total fixed assets (1 trillion)	Total profit before tax (100 billion)	Sales (1 trillion)
1998	154870	10.4	5.59	4.1	6.1	1.5	6.1
1999	154870	11.2	5.79	4.5	6.5	2.2	6.8
2000	162855	12.6	5.56	5.9	7.2	4.4	8.4
2001	169003	13.3	5.3	6.2	7.6	4.7	9.2
2002	181533	14.6	5.52	6.8	8.3	5.8	10.9
2003	196190	16.9	5.75	7.6	9.3	8.3	14.3
2004	278982	21.9	6.62	9.2	12.2	11.9	20.4
2005	271789	24.5	6.93	10.6	13.4	14.8	29.2
2006	301902	29.2	7.35	12.5	16	19.7	37.1
2007	336696	35.2	7.92	14.6	18.9	28.1	39.9

Note: The numbers are calculated with NBS data.

Table 3.2: Sum of firm size of China statistical year book

	Number of firms	Total assets (1 trillion)	Sum of employees (10 million persons)	Total equity (1 trillion)	Total fixed assets (1 trillion)	Total profit before tax (100 billion)
1998	165080	10.9	6.2	3.9	6.5	1.5
1999	162033	11.7	5.8	4.5	7.2	2.3
2000	162885	12.6	5.6	4.9	7.9	4.4
2001	171256	13.5	5.4	5.5	8.6	4.7
2002	181557	14.6	5.5	6	9.4	5.8
2003	196222	16.9	5.8	6.9	10.6	8.3
2004	276474	21.5	6.6	9	12.6	11.9
2005	271835	24.5	6.9	10.3	14.3	14.8
2006	301961	29.1	7.4	12.3	16.9	19.5
2007	336768	35.3	7.9	15	19.9	27.2

Source: China Statistical Yearbook (2007)

Table 3.3: Sample in Brandt et al. (2012)

	Firm Number	Employment	Sales
1998	165,118	5.64	6.8
1999	162,033	5.81	7.3
2000	162,883	5.37	8.6
2001	169,030	5.3	9.4
2002	181,557	5.52	11.1
2003	196,222	5.75	14.2
2004	279,092	6.63	20.2
2005	271,835	6.9	25.2
2006	301,961	7.36	31.7

Note: The data source is from Brandt et al. (2012)

3.4.2 Ownerships

As China is a transition economy, firm's capital in China is held by different investors. Our NBS data contains such information. The capital is held by six types of investors, namely the state; foreign investors; HMT investors (investors form Hong Kong, Macao and Taiwan); legal entities; individuals and collective investors. Many studies group China's firms into four main ownerships by using the capital distribution. They are state owned enterprises, private firms, foreign firms, and collective firms.

There are a large amount of firms' shares held by the state. In our sample, we group them as state owned enterprises (SOEs) if the state holds the majority of the shares (more than 50%). Basically, the state gets the shares from two ways. According to Wei et al. (2005), state shares are either retained by the state or shares are issued to the state through debt-equity swap when privatizing SOEs. Theoretically, these firms are owned by all the people of China, and their goal is to maximum public interests.

Private firms (labelled as private) refer to profit-making economic organizations, which can either be sole proprietorships, limited liability companies, or shareholding cooperatives (Poncet et al., 2010). These firms are owned by individuals. In our sample, there is one type of shareholders called legal entities. They refer to a mix of various domestic institutions and they are also known as institutional shareholders. In our sample we group them into private category. The reason given by Ding et al. (2013) is that the state's primary interest is political but legal entities are profit-oriented.

Foreign firms (labelled foreign) are invested by foreign entities including Hong Kong, Macao, and Taiwan. Collective firms (labelled collective) are defined as the firms owned collectively by communities in urban or rural areas. The production and property belonging to labouring masses and are managed by local government.

3.4.3 Descriptive statistics

Table 3.4 shows the summary statistics of key variables. We follow the method suggested by Guariglia et al. (2011). We start with 2,205,730 observations. We delete observations with negative sales; as well as observations with negative total assets minus total fixed assets; total assets minus liquid assets; and accumulated depreciation minus current depreciation. There are 2,960 observations dropped. We have 2,202,770 observations. We also drop 1 percent tails of the key variables (namely investment over capital ratio, cash flow over capital ratio, tangibility, liquidity and sales growth) to control for the potential influence of outliers. Finally, we have 2,076,691 observations. Moreover, the observation number of SOEs, private, foreign, and collective firms are 247,355, 1,237,006, 277,547, 195,233 respectively [9].

[9] There are also 73,041 observations have no major ownership (more than 50%) and 46,579 observations have no records of ownership. 64 observations have more than two major share holders. This may be caused by some mistakes.

Table 3.4: Summary statistics for key variables (outliers dropped)

	full sample	SOEs	private	foreign	collective	Diff(SOE & private)
I/K	8.73	3.51	10.09	10.32	6.14	0.00***
	(6.96)	(1.86)	(9.00)	(7.75)	(5.09)	
	{0.52}	{0.45}	{0.54}	{0.46}	{0.52}	
CFK	39.29	7.12	43.28	45.86	42.2	0.00***
	(5.31)	(2.57)	(20.62)	(21.45)	(17.50)	
	{0.79}	{0.44}	{0.79}	{0.90}	{0.86}	
asset growth	9.93	0.83	12.74	9.35	5.5	0.00***
	(4.58)	(-0.22)	(6.89)	(5.54)	(2.12)	
	{40.14}	{32.45}	{41.69}	{37.68}	{38.6}	
tangibility	36.31	45.98	35.53	32.12	35.01	0.00***
	(33.58)	(45.08)	(32.75)	(29.58)	(31.77)	
	{21.44}	{22.63}	{21.10}	{19.50}	{21.09}	
liquidity	5.11	-12.05	5.23	14.01	5.58	0.00***
	(6.06)	(-5.60)	(5.53)	(14.46)	(7.17)	
	{0.34}	{0.46}	{0.30}	{0.32}	{0.36}	
sales growth	11.77	0.74	15.58	12.36	5.37	0.00***
	(10.74)	(3.63)	(13.45)	(11.15)	(6.8)	
	{0.45}	{0.47}	{0.45}	{0.43}	{19.05}	
TFP growth	28.45	34.66	26.10	27.77	37.81	0.00***
	(16.29)	(13.39)	(16.61)	(16.13)	(16.11)	
	{0.97}	{1.21}	{0.88}	{1.02}	{1.12}	
size	9.69	10.02	9.52	10.33	9.42	0.00***
	(9.52)	(9.98)	(9.35)	(10.18)	(9.37)	
	{1.48}	{1.92}	{1.34}	{1.39}	{1.27}	
age	9.60	25.69	7.21	6.52	14.65	0.00***
	(6)	(25)	(5)	(6)	(11)	
	{11.24}	{17.18}	{8.80}	{4.23}	{11.69}	
Expdum	27.22	12.97	21.44	67.94	13.61	0.00***
	(0)	(0)	(0)	(1)	(0)	
	{0.445}	{0.336}	{0.410}	{0.466}	{0.343}	
Observations	2,076,691	247,355	1,237,006	277,547	195,233	

Notes: This table reports sample means, medians in round brackets, and standard deviations in curly brackets. I/K represents fixed asset investment over tangible fixed assets; CFK, cash flow over tangible fixed assets; asset growth, the percentage growth of tangible fixed assets; liquidity, current assets net of current liabilities over total assets; percentage growth of total sales. age is a firm's age. size is the logarithm of total assets. Expdum is the dummy variable which is 1 when a firm exports. All the means and medians in the table are percentages except age and size. Diff is the p-value associated with the t-test for differences in means of corresponding variables between SOEs and private firms. *** indicates significance at the 1% level.

Table 3.4 reports sample means, medians in round brackets, and standard deviations in curly brackets. SOEs invest less than other firms on average. Private firms and foreign firms invest higher than other kinds of ownerships. On average, their investment rates are 10.09% and 10.32%, respectively. We also find a high growth rate of private firms. The average total asset growth rate is 12.74% per annum. Besides, private and foreign firms also have the highest cash flow level. The ratios of cash flow to tangible fixed assets are 43.28% and 45.86%, and the ratios of cash flow to total assets are 11.18% and 8.56% respectively. It is not hard to find that the low cash flow level of SOEs may because the average size of SOEs is larger. Sales growth of private firms is also higher than SOEs. This is consistent with their high cash flow level.

Tangibility of SOEs (45.98%) is higher than other firms (there tangibility rate of private, foreign and collective firms are 32.75%, 29.58% and 31.77% respectively). TFP growth rates are close to each other, especially when we take a look at median values. In terms of firm's age, on average, SOEs are older while private and foreign firms are younger. The average size of private firms is smaller than SOEs and foreign firms. Foreign firms appear much higher average value of export dummy.

In the table we also report the the p-value associated with the t-test for differences in means of corresponding variables between SOEs and private firms. The the differences are statistically significant at the 1% level.

In general, we find that private firms are smaller and less tangible, but invest more and grow faster. State owned are older, bigger and more tangible, but they invest less and grow slower.

The correlations between variables are reported in Table 3.5. The correlations between variables are not large enough to indicate collinearity problem.

Table 3.5: Correlation Matrix

	I/K	sales growth	TFP growth	CFK	tangibility	liquidity	size	age	Expdum
I/K	1								
sales growth	0.145	1							
TFP growth	-0.0491	0.3216	1						
CFK	0.0007	0.1574	0.0629	1					
tangibility	0.0894	0.0365	0.0221	-0.2696	1				
liquidity	-0.0229	0.0308	0.0028	0.3004	-0.2777	1			
size	0.0534	0.0362	-0.0029	-0.0916	-0.0047	-0.0511	1		
age	-0.0797	-0.1405	-0.0041	-0.1261	0.0398	-0.1287	0.1794	1	
Expdum	0.0269	-0.0028	-0.0109	0.0032	-0.1138	0.0551	0.1865	-0.028	1

Notes: See Table 3.4 for definitions of all variables.

3.5 Empirical results

As many previous studies show (Allen et al., 2005; Guariglia et al., 2011; Ding et al., 2013), SOEs are least and private firms the most financially constrained. They are also the most important types of firms in China. Although we will report the results for all the groups, our discussion will highlight the differences between these two groups. We firstly report the estimation results of impulse response function. We apply impulse response function to estimate how investment opportunity shocks affect investment. As introduced above, we capture investment opportunities with three ways, TFP growth, sales growth and fundamental q.

3.5.1 Results of impulse response function

We firstly use panel VAR approach to find out how investment responds to different types of investment opportunities. The first order panel VAR model can be written as:

$$x_{i,t} = Ax_{i,t-1} + f_i + d_t + u_{it} \tag{3.21}$$

where x_{it} represent three-variable vectors $\{I/K,\ \text{q},\ CFK\}.f_i$ is a vector to capture unobservable firm specific effects. d_t is a vector of aggregate shock to all firms, and $u_{i,t}$ is a vector of disturbance terms, orthogonal to $x_{i,t-1}$.

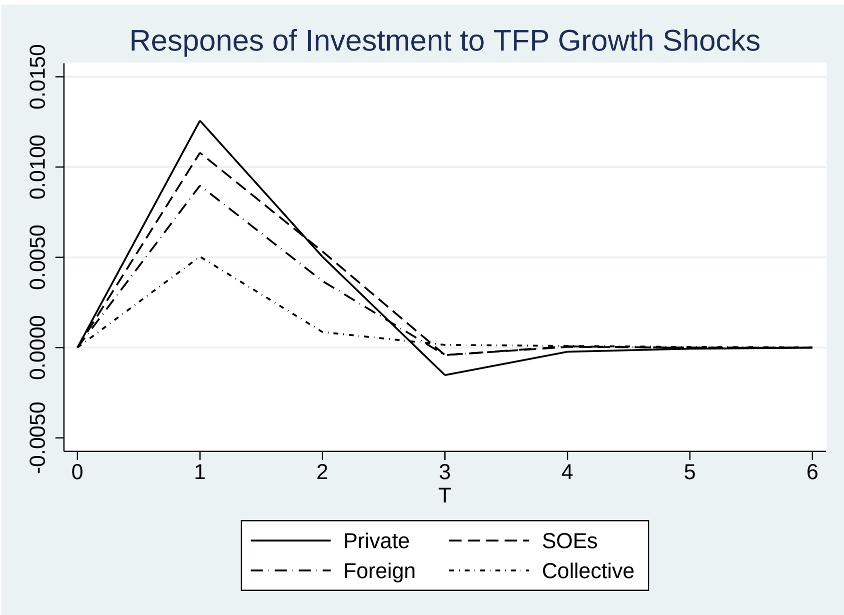

Figure 3.1: Investment and TFP growth shocks

We estimate the Equation (3.21) and Figure 3.1 plots the responses of investment to one standard deviation of TFP growth shocks. At year one, all firms positively respond to productivity shocks. Here we find that private firm's investment are most sensitive to TFP growth (a standard deviation shock of TFP growth can increase investment rate, I_t/K_t, around 0.012). The collective firms shows lowest response to productivity shocks (around 0.005). The difference between private firms and SOEs is not large. High sensitivity of investment to TFP growth implies that investment opportunities from supply side is significant and private firms care about them more.

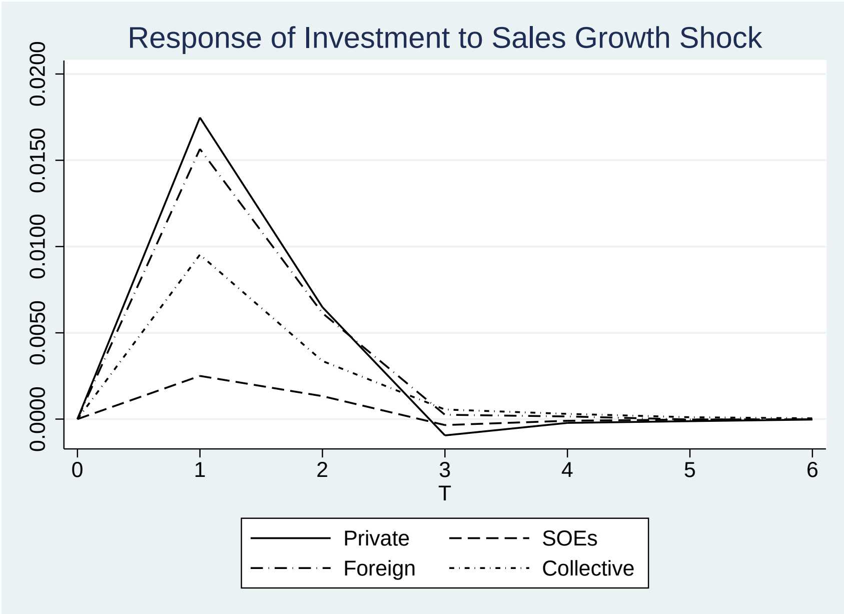

Figure 3.2: Investment and demand shocks

We then use sales growth as the proxy of q to capture the investment opportunity from demand side. Figure 3.2 plots the impulse response of investment and sales growth shocks. It is obvious that investment shows a positive response to demand shocks. Again we find that private firms show the highest response to shocks (a standard deviation shock of sales growth can increase investment rate, I_t/K_t, around 0.017). The response of investment from foreign firms is also very high. SOEs are not very sensitive to demand shocks here.

Comparing the result reported by Figure 3.1 and 3.2, we find that investment opportunities measured from supply and demand sides are different although they both have a positive impact on investment. Another implication is that investment choices are made from massive information and many indicators. Different types of firms may have different preferences. For example, SOEs are more sensitive to productivity shocks compared with the two others (foreign and collective), but they show the least sensitivity to demand shocks. However there is one thing unchanged, private firms show the highest response to investment opportunities in both supply and demand side.

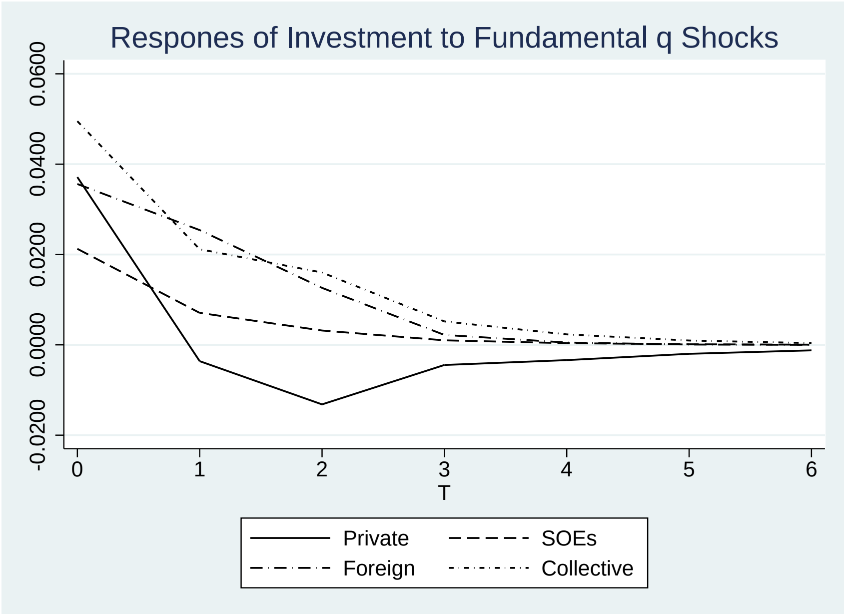

Figure 3.3: Investment and fundamental q

Figure 3.3 shows the impulse response of investment to fundamental q. As introduced above, we construct fundamental q according to Gilchrist and Himmelberg (1999). Since fundamental q is a forward looking variable, it is suggested to have contemporaneous impact on investment decisions. So we find that there are positive impacts at time zero. The fundamental q is estimated with lagged cash flow, TFP and sales[10]. Collective firms show the highest response to fundamental q shock. Although we find that private firms are not the most sensitive ones, SOEs still show a relatively low response.

3.5.2 SYS-GMM results

We also estimate the sensitivity with the system GMM. The purpose is to find consistency of the result with different methods to show the robustness of our results. The advantage of the system GMM over the impulse response method is that it could control more exogenous variables, but the method cannot measure the orthogonalised shock of one variable to investment.

[10]We introduce how to measure the fundamental q in the appendix.

Table 3.6: Investment TFP growth and cash flow

VARIABLES	(1)	(2)	(3)	(4)
TFP growth	0.454***			
	(0.0504)			
TFP growth*SOE		0.418**	0.472**	0.473***
		(0.183)	(0.192)	(0.173)
TFP growth*$PRIV$		0.571***	0.561***	0.475***
		(0.0608)	(0.0693)	(0.0587)
TFP growth*FOR		0.133	0.0789	0.139*
		(0.0820)	(0.0732)	(0.0821)
TFP growth*COL		0.302*	0.274*	0.258*
		(0.178)	(0.161)	(0.150)
CFK	0.146***	0.144***		0.139***
	(0.0131)	(0.0129)		(0.0159)
L.CFK			0.133***	
			(0.0153)	
Impact of TFP growth on I/K is the same across ownerships (p-value)		0.00***	0.00***	0.01***
Observations	1,082,949	1,082,573	758,366	758,366
m1	0	0	0	0
m3	0.635	0.554	0.637	0.555
Hansen test p-value	1.48e-05	7.17e-06	0.000173	2.38e-05

Notes: This table reports the estimation results of Q model using a system GMM estimator. SOE, $PRIV$, FOR and COL are ownership dummies for state owned, private, foreign, and collective firms respectively. Time dummies, industry dummies and time interacted with industry dummies are included. Instruments of first differenced equation are all the regressors lagged 3 times and more. Instruments of level equation are the regressors lagged by twice. Figures in parentheses are asymptotically standard errors. J is a test of over-identifying restrictions. $m1$ and $m3$ are test of 1st and 3rd serial correlations in the first-differenced residuals.

Table 3.6 shows the estimates of system GMM estimator of Equation (3.19). Instruments of first differenced equation are all the regressors lagged 3 times and more. Instruments of level equation are the regressors lagged by twice. Time dummies, industry dummies, and time interacted with industry dummies are included.

We use TFP growth to capture the investment opportunity from supply side. Column (1) reports the result of full sample. We find that TFP growth can significantly affect firm level investment, which is consistent with our prediction. The coefficient of cash flow term is significantly positive. This means the more cash flow a firm has at hand, the higher its investment is likely to be.

To compare the coefficients of relevant variables among firms owned by different agents, we use the interaction of TFP growth with ownership dummies. SOE, PRIV, FOR and COL are ownership dummies for state owned, private, foreign, and collective firms respectively. In column (2) we find that investment of private firms shows highest sensitivity to TFP growth. SOEs shows the second highest sensitivity. A χ^2 test suggests that the difference between the TFP growth coefficients of firms with different ownerships is statistically significant at the 1% level. The results are economically significant: TFP growth of private firms has more impact on investment than foreign and collective firms in terms of both magnitude and significance.

We then use lagged cash flow as an additional control to replace current cash flow. cash flow could have a lagged impact on investment. Using a lagged cash flow term is also consistent with our impulse response estimation, where we follow Gilchrist and Himmelberg (1999), who suggest cash flow term has a lagged impact on investment. In column (3), we find that the results are not changed very much compared with column (2). Private firms still show the highest sensitivity to TFP growth. This suggests that the coefficients of TFP are not sensitive to the change of cash flow.

The results in column (4) are estimated with the reduced sample, which is identical with the sample in column (3). This is to show our results are robust. The findings are in line with our impulse response results and confirms that private firms are most sensitive to TFP shocks. On the other, in column (4), the difference between TFP growth interacted with SOE and PRIV dummies is small. In Chen et al. (2011), they document that the sensitivity of investment expenditure to investment opportunities is significantly weaker for SOEs. However, our result suggests that if we capture investment from the supply side, investment of SOEs is not less efficient than private firms.

Third order autocorrelation of the differenced residuals does not indicate any problems with the validity of our instruments or the specification of the model.

Table 3.7: Investment TFP growth and cash flow

VARIABLES	(1)	(2)	(3)	(4)
Sales growth	0.834***			
	(0.0651)			
Sales growth*SOE		0.313	0.0391	0.293
		(0.318)	(0.219)	(0.309)
Sales growth*$PRIV$		0.931***	0.640***	1.239***
		(0.0841)	(0.0623)	(0.140)
Sales growth*FOR		0.833***	0.579***	0.864***
		(0.118)	(0.0871)	(0.173)
Sales growth*COL		0.123	-0.0627	-0.225
		(0.379)	(0.345)	(0.495)
CFK	0.0987***	0.110***		0.128***
	(0.0110)	(0.0114)		(0.0172)
L.CFK			0.113***	
			(0.0130)	
Impact of sales growth on I/K is the same across ownerships (p-value)		0.00***	0.00***	0.00***
Observations	1,239,734	1,239,222	819,911	819,911
m1	0	0	0	0
m3	0.333	0.205	0.126	0.167
Hansen test p-value	1.60e-08	7.15e-08	2.30e-08	0.000867

Notes: This table reports the estimation results using a system GMM estimator. SOE, $PRIV$, FOR and COL are ownership dummies for state owned, private, foreign, and collective firms respectively. Time dummies, industry dummies and time interacted with industry dummies are included. Instruments of first differenced equation are all the regressors lagged 3 times and more. Instruments of level equation are the regressors lagged by twice. Figures in parentheses are asymptotically standard errors. J is a test of over-identifying restrictions. $m1$ and $m3$ are test of 1st and 3rd serial correlations in the first-differenced residuals.

In Table 3.7, we replace TFP growth to sales growth to find investment sensitivity to demand shocks. We present the results estimated with system GMM. The instrument sets are all the regressors lagged 3 times and longer for the first differenced equation and lagged twice for the level equation. Time dummies, industry dummies, and time interacted with industry dummies are included.

The results in full sample is consistent with theoretical prediction that investment is positively related to sales growth. In column (2), we find that SOEs and collective firms are not significantly sensitive to demand shocks, while the other firms show very high sensitivities towards demand shocks. The results suggest that demand shocks are important for non-state owned firms. They care more about the demand market, and use market demand to form their investment decisions. As SOEs are supported by the government, they are less subject to market forces. A χ^2 test suggests that the difference between the sales growth coefficients of firms with different ownerships is statistically significant at the 1% level. The result is consistent with Chen et al. (2011), that investment of SOEs is less efficient[11]. Using sales growth as the measurement of investment opportunity is economically meaningful for private and foreign firms.

There is another explanation of low investment-investment sensitivity which is attributed to unrealistically high marginal adjustment costs and therefore implausibly slow adjustment speeds Whited (1994). High capital adjustment costs and slow adjustment speeds can be used to explain why SOEs are not significantly sensitive to sales growth. However, in Table 3.6, investment of SOEs is significantly sensitive to TFP growth. Therefore, the reason of different investment-investment opportunity sensitivity is because of different preference in investment opportunities, rather than heterogeneous adjustment costs. There is some evidence that firms have different preferences.

We also compare the results in column (3) and (4). In addition, the results in column (3) and (4) are estimated with the same sample. We find that the results change dramatically when we replace current the cash flow term with the lagged. The change is economically significant: the coefficient of Sales growth*$PRIV$ in column (3) is 0.640, it is almost doubled in column (4). The results suggest that cash flow term contains some information of investment opportunities especially from demand side.

In our theoretical model, we decomposed the marginal q to demand and supply components. Comparing the results of Table 3.6 and 3.7, we find two differences between TFP and sales growth. First, the linear combination of investment opportunities are different regarding different ownerships. For example, we can find that TFP has significantly positive impact on investment of SOEs but sales growth has not. Second, sales growth contains more information of a firm's cash flow[12], but TFP growth is less

[11] In the absence of a perfect capital market , a variety of frictions (such as information asymmetries, agency problems and measurement errors) have been identified in the empirical literature which make firms' investment expenditure less sensitive to investment opportunities (see, Fazzari et al., 1988; Erickson and Whited, 2000). Thus, high sensitivity of investment to investment opportunity is regarded as a signal of high investment efficiency.

[12] As we mentioned above. The coefficients of TFP growth and sales growth show different sensitivities when we change current cash flow term to lagged cash flow.

related information of internal finance. The two differences suggest that the nature of investment opportunities are different and decomposing investment opportunities to demand and supply sides is valid.

We then use fundamental q (FQ) as the measurement of investment opportunities. The estimates are system GMM estimator, which are reported in Table 3.8. The instrument sets are the regressor, fundamental q, lagged 3 times and longer for the first differenced equation and lagged twice for the level equation. Time dummies, industry dummies, and time interacted with industry dummies are included. Since the fundamental q is a proxy used to estimate future profit with lagged values, it is highly correlated with current cash flow. There will be colinearity problem. So, cash flow is not controlled in the estimation.

Our results suggested that investment of private and collective firms most sensitive to fundamental q. Their investment decisions are more concerned with profit in short future. Again, the response of SOEs to fundamental q is not significant. Private, foreign and collective firms show significant investment-investment opportunity sensitivity. However, the χ^2 test suggests that the difference between the FQ coefficients of firms with different ownerships is not statistically significant.

Overall, our GMM results are generally consistent with our panel VAR results. With different methodology and different measurement of q, our results show strong evidence that private firms value investment opportunities more from both supply/demand sides, and forward looking term.

Table 3.8: Investment, fundamental q and cash flow

VARIABLES	(1)	(2)
FQ	0.0957***	
	(0.0155)	
FQ*SOE		0.0603
		(0.0838)
FQ*$PRIV$		0.110***
		(0.0216)
FQ*FOR		0.0684**
		(0.0319)
FQ*COL		0.0913***
		(0.0285)
Impact of FQ on I/K is the same across ownerships (p-value)		0.673
Observations	432,325	432,273
m1	0	0
m3	0.921	0.917
Hansen test p-value	0	0

Notes: This table reports the estimation results using a system GMM estimator. SOE, $PRIV$, FOR and COL are ownership dummies for state owned, private, foreign, and collective firms respectively. Time dummies, industry dummies and time interacted with industry dummies are included. The instrument sets are all the regressors lagged 3 times and longer for the first differenced equation and lagged twice for the level equation. Figures in parentheses are asymptotically standard errors. J is a test of over-identifying restrictions. $m1$ and $m3$ are test of 1st and 3rd serial correlations in the first-differenced residuals.

3.5.3 Robustness tests

We conduct a number of robustness tests and estimate the Equation 3.20, the extended model. The results are reported as follows.

Table 3.9: Robustness: investment TFP growth and additional control variables

VARIABLES	Full	SOEs	Private	Foreign	Collective
TFP growth	0.248***	0.0862***	0.275***	0.0950***	0.0789**
	(0.0161)	(0.0268)	(0.0339)	(0.0313)	(0.0356)
CFK	0.120***	0.120**	0.143***	0.0772***	0.143***
	(0.0108)	(0.0588)	(0.0141)	(0.0202)	(0.0371)
Tangibility	-0.310***	-0.168**	-0.392***	-0.178**	-0.158
	(0.0346)	(0.0656)	(0.0480)	(0.0790)	(0.110)
Liquidity	-0.0413*	0.0290	-0.0759**	-0.0496	-0.00453
	(0.0235)	(0.0363)	(0.0360)	(0.0424)	(0.0859)
Size	0.0392***	0.0373***	0.0332***	0.0355***	0.0417***
	(0.00401)	(0.00902)	(0.00571)	(0.00869)	(0.0159)
Age	-0.00136***	-0.00104***	-0.00131***	-0.00602***	-0.000601
	(0.000138)	(0.000376)	(0.000198)	(0.000787)	(0.000454)
Expdum	-0.0971***	-0.00732	-0.0788**	-0.0201	0.255**
	(0.0234)	(0.0658)	(0.0308)	(0.0337)	(0.124)
Observations	803,379	63,751	511,847	135,838	62,866
m1	0	0	0	0	0
m3	0.434	0.926	0.518	0.471	0.210
Hansen test p-value	0	0	0	6.89e-11	0.00119

Notes: This table reports the estimation results using a system GMM estimator. Time dummies, industry dummies, time interacted with industry dummies are included. The instrument sets are all the regressors except age lagged 3 and 4 times for the first differenced equation and lagged twice for the level equation. Figures in parentheses are asymptotically standard errors. J is a test of over-identifying restrictions. $m1$ and $m3$ are test of 1st and 3rd serial correlations in the first-differenced residuals.

Table 3.10: Robustness: investment sales growth and additional control variables

VARIABLES	Full	SOEs	Private	Foreign	Collective
Sales growth	0.358***	0.158***	0.590***	0.263***	0.247***
	(0.0135)	(0.0367)	(0.0239)	(0.0527)	(0.0356)
CFK	0.119***	0.130**	0.167***	0.0885***	0.120***
	(0.00956)	(0.0535)	(0.00724)	(0.0186)	(0.0299)
Tangibility	-0.305***	-0.174***	-0.549***	-0.227***	-0.0956
	(0.0314)	(0.0600)	(0.0476)	(0.0800)	(0.107)
Liquidity	-0.0629***	0.00147	-0.113***	-0.0695*	-0.00833
	(0.0207)	(0.0317)	(0.0348)	(0.0394)	(0.0860)
Size	0.0334***	0.0388***	0.0297***	0.0329***	0.0265*
	(0.00364)	(0.0101)	(0.00566)	(0.00830)	(0.0154)
Age	-0.000920***	-0.00107***	6.64e-05	-0.00236**	-0.000308
	(0.000132)	(0.000392)	(0.000170)	(0.00114)	(0.000462)
Expdum	-0.0597***	-0.00643	0.0365	-0.0655*	0.168
	(0.0212)	(0.0590)	(0.0307)	(0.0338)	(0.106)
Observations	919,028	78,624	570,467	163,084	72,901
m1	0	0	0	0	0
m3	0.581	0.894	0.692	0.570	0.0973
Hansen test p-value	0	0	0	0	0.000345

Notes: This table reports the estimation results using a system GMM estimator. Time dummies, industry dummies, time interacted with industry dummies are included. The instrument sets are all the regressors except age lagged 3 and 4 times for the first differenced equation and lagged twice for the level equation. Figures in parentheses are asymptotically standard errors. J is a test of over-identifying restrictions. $m1$ and $m3$ are test of 1st and 3rd serial correlations in the first-differenced residuals.

Table 3.11: Robustness: investment, fundamental q and additional control variables

VARIABLES	Full	SOEs	Pirvate	Foreign	Collective
FQ	0.107***	0.0516	0.120***	0.0527***	0.107***
	(0.00610)	(0.0399)	(0.00832)	(0.0119)	(0.0199)
Tangibility	-0.251***	-0.237***	-0.313***	-0.197**	-0.221**
	(0.0276)	(0.0598)	(0.0361)	(0.0840)	(0.107)
Liquidity	-0.0601***	0.0224	-0.0703**	-0.0677	0.0333
	(0.0203)	(0.0399)	(0.0293)	(0.0431)	(0.0862)
Size	0.0387***	0.0504***	0.0284***	0.0397***	0.0627***
	(0.00395)	(0.00949)	(0.00488)	(0.00994)	(0.0194)
Age	-0.00210***	-0.00161***	-0.00208***	-0.00359***	-0.000921**
	(0.000112)	(0.000347)	(0.000140)	(0.000643)	(0.000469)
Expdum	-0.0249	0.130**	-0.0138	0.0502*	0.313***
	(0.0212)	(0.0656)	(0.0279)	(0.0282)	(0.117)
Observations	294,396	26,134	175,255	57,953	23,063
m1	0	0	0	0	0
m3	0.518	0.959	0.243	0.318	0.503
Hansen test p-value	0	0.000543	0	0	0.00928

Notes: This table reports the estimation results using a system GMM estimator. Time dummies, industry dummies, time interacted with industry dummies are included. The instrument sets are all the regressors except age lagged 3 and 4 times for the first differenced equation and lagged twice for the level equation. Figures in parentheses are asymptotically standard errors. J is a test of over-identifying restrictions. $m1$ and $m3$ are test of 1st and 3rd serial correlations in the first-differenced residuals.

Table 3.9, 3.10 and 3.11 report the results of our expanded model (see equation 3.20). The three tables report the estimation results using a system GMM estimator. The instrument sets are all the regressors (except age) lagged 3 and 4 times for the first differenced equation and lagged twice for the level equation. Time dummies, industry dummies, time interacted with industry dummies are included. We capture size effect and also financial variables such as tangibility and liquidity. The results again suggest that TFP growth have the most significant impact on private firms. This can also be found in sales growth. Besides, we also find that when we control different variables, coefficients of sales growth is very volatile, but TFP growth is relatively stable. This result also highlights the motivation of our study. Sales growth could be used to measure demand shocks, but it is less preferable to study investment and investment opportunities because it is correlated with many other variables.

The result suggests that whatever variables we control, SOEs are not as sensitive to sales growth as other firms. There could be three possibilities behind this phenomenon. First, SOEs are not as efficient as private firms. Second, they are efficient but most of them are large firms with high capital stocks. To keep efficiency, they choose to invest less compared with small firms. This idea is also introduced in Riddick and Whited (2009). Third, they are efficient and more investment will not affect their efficiency, but they may still show low sensitivity to investment opportunities. This is because they are supported by the government, and they are also led by government policies. So they are more sensitive to policies but not markets. For example, during the financial crisis, private firms will 'wait and see', but SOEs are encouraged to invest more. Private firm's investment is more sensitive to cash flow than SOEs[13], which is consistent with the literature that find private firms are more financially constrained (Allen et al., 2005; Guariglia et al., 2011; Ding et al., 2013).

We find that tangibility has significant negative impacts on investment in all the three tables when we estimate the full sample. This is consistent with Hovakimian (2009) that with lower asset tangibility are usually found to operate in industries with higher growth potential, and therefore, firms investment more. Liquidity displays non positive coefficients. There are two possible explanations: when investment opportunities are not good, firms tend to hold more cash (Riddick and Whited, 2009), therefore the liquidity will increase. In addition, Ding et al. (2013) argue that high liquidity could alleviate financial constraint problems, but could be detrimental to profitability.

The coefficients on size reported in Table 3.9, 3.10 and 3.11 show a significantly positive sign. This sign suggests that larger firms invest more. In Guariglia (2008), size is an indicator of asymmetric information. Larger firms are less likely to face financing constraint problem. Firm age is also an indicator of asymmetric information, but we find no positive impact of firm age on investment [14].

The coefficients of export dummy are not consistent among the tables. There could be two reasons. First, different investment opportunities may contain information of export behaviour. Second, the sample size of these three tables are different because we use different investment-opportunities and further research is needed to answer this question.

[13] See Table 3.9, 3.10. In Table 3.11, cash flow is not included because FQ is estimated by current and lagged cash flow. The correlation between FQ and cash flow is very high.

[14]The negative effect of age is statistically significant in all groups of firms except collective firms in table 3.9 and 3.10 and private firms in table 3.10.

3.6 Conclusion

In this chapter, we study the relationship between investment and investment opportunities from both theoretical and empirical perspectives. Theoretically we decompose the Q model and find that investment could be measured supply side and demand side together. We also introduce TFP growth as an important component of investment opportunities. Empirically, we use a panel of over 600,000 firms from 1998 to 2007 to find the linkage between investment opportunities and financial constraints. With two different estimation methods, panel VAR and the system GMM, and four different proxies for investment opportunities (from forward looking to backward looking), we find that private firms have a higher investment-investment opportunity sensitivity.

The results show that constrained firms value investment opportunities more. Investment of private firms in China is more sensitive to investment opportunities from demand side, supply side and also the forward looking values. However, compared with private firms, investment of SOEs are less sensitive to investment opportunities, especially from the demand side. This is one crucial reason to explain why financially constrained firms invest more than unconstrained. The financial constraints problem may be overstated in China. The finding is also a complement to previous arguments that financial constraints could be solved by alternative financing channels (Allen et al., 2005) and high profitability (Guariglia et al., 2011).

The policy implications of the findings are that policymakers can stimulate corporate investment through different channels. If policymakers aim to increase private firms' investment, they can implement policies to increase demand. When it comes to state owned firms, policymakers can encourage them to invest more on R&D to increase TFP growth speed and subsequently, increase fixed capital investment.

There are also some limitations to this chapter. First, we do not have market data, so we cannot compare our results with some influential papers. Second, although we measure marginal q with 3 proxies, all of these proxies have some problems. For example, even though we suggest that FQ is forward looking, it is still highly correlated with lagged variables. Third, the estimation methods we use also have some issues. Panel VAR suggested by Love and Zicchino (2006) cannot control exogenous variables and the system GMM results are sensitive to the choice of instruments.

This chapter also suggest a new question of our future study. We need to find why SOEs are not sensitive to investment opportunities.

Appendix

3.A Forecast q with profit

The second method is suggested by Gilchrist and Himmelberg (1995) through the estimation of a set of VAR. We improve the estimation of marginal q compared with Gilchrist and Himmelberg (1995) as we consider investment opportunity from both supply side and demand side. We suggest a vector, $x_{i,t}$, which comprises a firm's observable growth rate which are part of information set $\Omega_{i,t}$, and $x_{i,t}$ follows a stationary stochastic process with a frist-order autoregressive representation. According to Gilchrist and Himmilburg (1995), and the observable fundamentals vector $x_{i,t}$ contains profit rate (π), TFP (TFP) and sales rate ($sales$). This process could be written as:

$$x_{i,t} = Ax_{i,t-1} + f_i + d_t + u_{i,t}$$

where f_i is a vector to capture unobservable firm specific effects. d_t is a vector of aggregate shock to all firms, and $u_{i,t}$ is a vector of disturbance terms, orthorgnal to $x_{i,t-1}$. Since the process is assumed stationary, the expectation of $x_{i,t+s}$ given $x_{i,t}$ could be interpreted as (Bontempi et al., 2004):

$$E[x_{i,t+s}|x_{i,t}] = A^s x_{i,t}$$

where f_i and d_t are omitted. The profit growth rate $\widehat{FQ_{i,t}}$ could be finally estimated as

$$\begin{aligned}
\widehat{FQ_{i,t}} &= \sum_{s=1}^{\infty} \lambda^s E[\pi_{i,t+s}|\Omega_{i,t}] \\
&= \sum_{s=1}^{\infty} \lambda^s E[c' x_{i,t+s}|x_{i,t}] \\
&= \sum_{s=1}^{\infty} c' \lambda^s \widehat{A}^s x_{i,t} \\
&= c'(I - \lambda \widehat{A})^{-1} x_{i,t}
\end{aligned}$$

,where $\lambda = \beta(1-\delta)$. The matrix notation could be expressed as:

$$\widehat{FQ} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \end{bmatrix} \left[I - \lambda \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} & a_{16} \\ 1 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} & a_{36} \\ 0 & 0 & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & a_{56} \\ 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \right]^{-1} \begin{bmatrix} \pi_{i,t-1} \\ \pi_{i,t-2} \\ TFP_{t-1} \\ TFP_{t-2} \\ sales_{t-1} \\ sales_{t-2} \end{bmatrix},$$

where c is a conformable vector of zeros with a one in the jth row when $\pi_{i,t}$ is the jth element of $x_{i,t}$; $\widehat{A}$ is the estimated coefficient matrix form VAR.

Since our data only covers 8 years, the time period will be significantly shrunk if we set too many lag when forecasting $\widehat{F_{i,t}}$. If we set VAR lag 2 years, and β equals to 0.8 (Gilchrist and Himmelberg (1995) set $\delta = 0.15$ and $\beta = 0.94$. This is because when β values between 0.7 and 0.9, neither coefficient values nor test statistics are significantly distorted.) Practically we omitted sales when forecasting FQ, this is because sales is highly correlated with profit.

3.B Description of dataset

Table (3.B.1) shows the number of firms each year. The observations of full sample are increasing over the years, but SOEs and collective firms are decreasing. This is consistent with privatization reform after 1998 (Haggard and Huang, 2008). The number of SOEs and collective firms shrink 70.8% and 53.8% respectively. At the same time, private and foreign firms increase dramatically. The observations in 2007 are 4.91 and 3.17 times as large as those in 1998. The data illustrates a significant growth in the private sector.

There is one problem when summarizing observations. We find the sum of these five types of firms does not equal to the total observations of the full sample. There are two reasons. First, there are 74,593 observations' information of capital distribution is missing. Second, there are some errors in the dataset. (i.e. if we allow an error of one percent, there are 75 observations whose sum of capital held by different investors is more than one percent larger than total capital and 11445 observations more than 1 percent smaller than total capital. At the same time, 71 observations have two types of ownerships.)

Table 3.B.1: Number of observations

	full sample	SOEs	Private	Foreign	Collective
1998	154870	41763	51304	15404	30532
1999	154870	37110	49427	13856	25652
2000	162855	37434	66840	18524	27585
2001	169003	31674	81463	20908	23049
2002	181533	28600	97390	23481	21361
2003	196190	23648	117086	27086	18582
2004	278982	23679	185102	40773	17029
2005	271789	17747	188771	40824	15022
2006	301902	15910	217084	43986	14315
2007	336696	12180	252032	48858	14120

Private firms are growing and SOEs are shrinking in our sample period. It is still not clear how many firms have entered and exited each year. Table (3.B.2) shows firms which enter and exit aggregately. More importantly, we could track ownership structure changes with the data. Firms in our dataset have a unique firm ID, this could be used to study firms' entry and exit. According to Brandt et al. (2012), firms in China occasionally receive a new ID if they go through restructuring, merger or acquisition. They also used the other information such as firm's name, industry, address, etc. to link them. In our version, this method is not reliable. There are several problems which cannot be solved. First, our data does not have firms' names. Brandt et al. (2012) link firms with address using postcode, but in our data, most firms in China do not use a unique postcode, and some postcodes are used by more than 100 firms. These postcodes sometimes could only be used to represent a city or a province. Therefore, we match firms with firm ID only.

Table (3.B.2b) shows that almost every year, ten to thirty percent of firms exit the 'above scale' dataset. We find that in 1999 and 2000, only about 70% firms existed in the previous year, but this figure increase to more than 90% in 2007. Almost thirty percent of firms exit or change their firm ID shows that firm-level structural change is very significant in 1999 and 2000. This result could be used to explain China's privatization reform in 1998.

From Table (3.B.3) we find that every year, there are many firms enter and exit the dataset. However, we found that in 2004, there are 134,533 firms which enter the dataset, which is 93.3% as large as the firms which exist last year. That is to say, in 2004, nearly half of the 'above scale' firms are newly entered. In 2003 and 2004, there are large numbers of firms, 51,841 and 48,666 respectively, who exit NBS dataset, but this number decreases in 2005 and 2006.

Table 3.B.2: Fraction of observations matched to previous year observations

(a) Matched by firm ID

Year	Full sample	Firms exist last year	Number of SOEs	Number of private	Number of foreign	Number of Collective
1998	154870					
1999	154870	154870	35698	45997	13401	23906
2000	162855	112462	30180	41285	12692	19478
2001	169003	119413	26678	48768	15993	17642
2002	181533	142982	25554	70424	19031	18099
2003	196190	149051	21280	81724	21271	15641
2004	278982	144349	16116	86476	23708	10789
2005	271789	230316	16354	155177	36173	13187
2006	301902	244919	14775	170463	37820	12562
2007	336696	273106	10914	198933	40936	12266

(b) Comparison of matched firms

Year	Matched by firm ID (total)	Matched by ID& ownership	Differential	Percentage matched by ID	Percentage matched by ID& ownership	Differential
1999	154870	124816	30054	100.00%	80.60%	19.40%
2000	112462	109292	3170	72.60%	70.60%	2.00%
2001	119413	116113	3300	73.30%	71.30%	2.00%
2002	142982	139830	3152	84.60%	82.70%	1.90%
2003	149051	146558	2493	82.10%	80.70%	1.40%
2004	144349	142280	2169	73.60%	72.50%	1.10%
2005	230316	228003	2313	82.60%	81.70%	0.90%
2006	244919	242260	2659	90.10%	89.10%	1.00%
2007	273106	270680	2426	90.50%	89.70%	0.80%

Table 3.B.3: Firms enter and exit

year	Enter	Exit
1999		42408
2000	50393	43442
2001	49590	26021
2002	38551	32482
2003	47139	51841
2004	134633	48666
2005	41473	26870
2006	56983	28796
2007	63590	

From Table (3.B.3) we find that every year, there are many firms enter and exit the dataset. However, we found that in 2004, there are 134,533 firms entered the dataset, which is 93.3% as large as the firms exist last year. That is to say, in 2004, nearly half of the 'above scale' firms are newly entered. In 2003 and 2004, there are large numbers of firms, 51,841 and 48,666, exit NBS dataset, but this number decreases in 2005 and 2006.

Table 3.B.4: Total assets

(a) Sum of total assets (1 trillion yuan)

Year	SOEs	Private	Foreign	Collective
1998	4.33	2.78	1.22	0.77
1999	4.38	2.94	1.27	0.72
2000	4.97	4.2	1.68	0.73
2001	5.06	4.63	1.86	0.63
2002	5.14	5.63	2.12	0.62
2003	5.48	6.89	2.69	0.61
2004	6.42	9.32	3.74	0.7
2005	6.65	11.3	4.34	0.64
2006	7.33	14	5.24	0.68
2007	8.35	17.7	6.4	0.82

(b) Percentage increase of total assets

	SOEs	private	foreign	collective
1999	1.20%	5.80%	4.10%	-6.50%
2000	13.50%	42.90%	32.30%	1.40%
2001	1.80%	10.20%	10.70%	-13.70%
2002	1.60%	21.60%	14.00%	-1.60%
2003	6.60%	22.40%	26.90%	-1.60%
2004	17.20%	35.30%	39.00%	14.80%
2005	3.60%	21.20%	16.00%	-8.60%
2006	10.20%	23.90%	20.70%	6.90%
2007	13.90%	26.40%	22.10%	19.20%

We find that the number of state owned firms drops (from 41,763 to 12,180), but the shrinkage of the state sector could not be found when we summarise the sum of total assets (Table (3.B.4a)). The total asset of SOEs increases every year. The result interprets that many state owned firms have transformed their ownerships and state capital is more concentrated in large firms. That is why firm number decreases more than 70% but the sum of total assets increases 92.8%. On the other hand, this shows that on average, the asset growth of SOEs is very high.

The total assets of private and foreign firms grow faster than SOEs. Except the data of 1999, in which we believe there are some mistakes (the number of observations and firm's IDs 100% matches with date of 1998. It is implausible that there is no firm enter or exit in 1999), we find that private and foreign firms keep growing at two-digit growth rates (Table (3.B.4b)). The total assets of collective firms are relatively small and the growth rate is the lowest compared with other firms.

If we compare the growth rate of total assets by year, we could find that in 2004, total assets grow faster than other years despite different ownership. Our result is consistent with Allen et al. (2005), as they document that the private sector grows much faster.

Table (3.B.4) indicates that the private sector is growing and becomes the largest sector since 2002. This means private investors control the largest proportion of firm's assets in China. The private sector has a more significant impact on China's economy.

Table (3.B.5a) summarises firm's profit at an aggregate level. For the private sector, the sum of profit is higher than other sectors since 1998 and the aggregate profit grows from 52 billion to 1.48 trillion RMB. We also find that the total profit of SOEs is very close to that of foreign firms. Collectively owned firms have the lowest aggregate profit.

Table (3.B.5b) shows that the aggregate profit growth rate of SOEs is very high, especially in 1999 and 2000, at the beginning of privatization. The increase of growth rates are 462.5% in 1999 and 77.8% in 2000 respectively. Private firms and foreign firms' growth rates reach the peak in 2000. They are 169.3% and 102.0% respectively. It is interesting to see that during privatization, the number of SOEs is cut, and state capital is concentrated to control large firms, but the sum of profit grows very fast in the sample period. This also indicates that privatization may help SOEs become more efficient, and the private sector becomes larger.

Comparing Table (3.B.4b) with Table (3.B.5b)) we find that profit growth is faster than total asset. Generally, firms in China are becoming more efficient in the sample period.

Table 3.B.5: Total profits

(a) Sum of total profits before tax (100 million yuan)

	SOEs	private	foreign	collective
1998	0.08	0.52	0.22	0.24
1999	0.45	0.75	0.4	0.24
2000	0.8	2.02	0.82	0.3
2001	0.91	2.1	0.91	0.27
2002	1.07	2.65	1.19	0.31
2003	1.71	3.7	1.72	0.39
2004	2.51	5.48	2.44	0.47
2005	3.64	6.98	2.79	0.53
2006	3.92	9.82	3.77	0.6
2007	5.12	14.8	5.12	0.84

(b) Percentage increase of total profits before tax

	SOEs	private	foreign	collective
1999	462.50%	44.20%	83.60%	0.00%
2000	77.80%	169.30%	102.00%	24.60%
2001	14.30%	4.00%	12.00%	-9.00%
2002	17.10%	26.20%	30.20%	15.10%
2003	59.80%	39.60%	44.50%	24.30%
2004	46.80%	48.10%	41.90%	20.80%
2005	45.00%	27.40%	14.30%	12.10%
2006	7.70%	40.70%	35.10%	13.50%
2007	30.60%	50.70%	35.80%	40.50%

Table 3.B.6: Summary statistics for key variables (original data)

	(1) full sample 1	(2) full sample 2	(3) SOEs	(4) private	(5) foreign	(6) collective
I/K	-53.26	-159.05	-656.44	-76.57	-55.79	-140.51
	(6.85)	(6.86)	(1.65)	(8.95)	(7.9)	(4.97)
	{19.06}	{5.46}	{14.69}	{1.60}	{0.72}	{1.06}
CFK	192.42	76.87	35.12	85.35	83.58	65.08
	(17.57)	(17.62)	(2.25)	(20.74)	(21.53)	(17.47)
	{16.32}	(10.94)	{2.44}	{0.79}	{0.38}	{0.32}
asset growth	9.05	9.313	-1.00	12.2	8.93	4.26
	(4.30)	(4.37)	(-0.54)	(6.68)	(5.40)	(1.87)
	{0.47}	{0.46}	{0.42}	{0.47}	{0.43}	{0.45}
Tangibility	56.26	56.49	126.43	52.57	31.32	34.89
	(33.00)	(32.97)	(45.09)	(32.23)	(28.65)	(31.09)
	{2.08}	{2.10}	{4.13}	{1.95}	{0.23}	{0.87}
Liquidity	7.16	5.11	-15.38	6.72	15.75	8.73
	(7.38)	(6.15)	(-2.05)	(6.27)	(16.16)	(9.96)
	{3.00}	1.82	{9.53}	{2.59}	{0.34}	{14.12}
Sales growth	11.5	11.89	-2.6	16.44	12.62	3.45
	(10.66)	(10.81)	(3.13)	(13.59)	(11.08)	(6.57)
	{0.62}	{0.61}	{0.79}	{0.58}	{0.54}	{0.61}
size	9.66	9.68	9.94	9.51	10.30	9.39
	(9.50)	(9.51)	(9.90)	(9.33)	(10.16)	(9.34)
	{1.50}	{1.48}	{1.97}	{1.35}	{1.40}	{1.29}
age	9.56	9.56	25.38	7.14	6.50	14.55
	(6)	(6)	(24)	(5)	(6)	(11)
	{11.21}	{ 11.21}	{17.17}	{8.73}	{ 4.25}	{11.64}
Expdum	26.77	26.78	12.29	21.05	67.45	13.46
	(0)	(0)	(0)	(0)	(1)	(0)
	{0.442}	{0.442}	{0.328}	{0.407}	{0.468}	{0.341}
Observations	2,205,730	2,155,147	269,768	1,306,559	293,712	207,294

Notes: This table reports sample means, medians in round brackets, and standard deviations in curly brackets. I/K represents fixed asset investment over tangible fixed assets; CFK, cash flow over tangible fixed assets; asset growth, the percentage growth of tangible fixed assets; liquidity, current assets net of current liabilities over total assets; percentage growth of total sales. age is a firm's age. size is the logarithm of total assets. Expdum is the dummy variable which is 1 when a firm exports. All the means and medians in the table are percentages except age and size. Full sample 1 reports the summary statistics of the full sample (no observations excluded). Full sample 2 summarizes the sample which excludes the observations without ownership information.

Table (3.B.6) shows the summary statistics of key variables. The data we use are original. We find that the means are very different from medians. This shows the data is highly skewed, especially when we take a look at the investment rate and cash flow. It is not reasonable that in China the average investment rate is negative, and on average cash flow is higher than firms' total assets. Therefore we need to cut the outliers.

We summarize the full sample, and report the results in ‘full sample 1’. However, the means of I/K and CFK of full sample are higher than the same variable for SOEs, private, foreign, and collective firms. The reason is because there are a small proportion of observations that do not have ownership information. In ‘full sample 1’, these observations are not removed from the full sample.

We then summarize the sample from which the observations without ownership information are removed. The results are reported in ‘full sample 2’. The means and medians of ‘full sample 2’ lie among the values of same variables for different ownerships.

Table (3.B.7) illustrates that all values shows a decreasing trend except tangibility and leverage ratio when state capital increases. This is consistent with our finding, that SOEs are less constrained but grow slower than other firms. However, it is more interesting if we take a look at the effect of foreign capital.

Table (3.B.8) shows that investment rate shows a U-shape curve when recipients get more foreign capital. The average investment rate decreases from 12.19 to 10.99 and increases from 10.99 to 13.27. This U-shape curve could also be found in asset growth rate, cash flow, tangibility and sales growth while liquidity shows an inverted U-shape curve. We can also find that the leverage ratio is decreasing when foreign capital increase. This shows that firms with higher foreign capital are less externally funded.

Table 3.B.7: Means of key variables with different state ownership

	$Stacap = 0\%$	$0\% < statecap \leq 25\%$	$25\% < statecap \leq 50\%$	$50\% < statecap \leq 75\%$	$75\% < statecap < 100\%$	$statecap = 100\%$
I/K	13.28	10.45	9.42	7.89	6.29	6.25
CFK	40.21	24.37	25.97	19.24	6.76	6.55
asset growth	11.97	6.97	4.68	3.26	1.57	1.37
leverage ratio	57.37	61.41	59.03	64.38	73.21	73.58
tangibility	34.91	37.61	37.55	37.53	46.08	46.36
liquidity	6.68	2.67	5.54	0.3	-12.33	-12.75
sales growth	14.15	8.06	5.81	4.01	1.3	1.13

Notes: This table reports the means of difference groups. *stacap* is the percentage of shares held by state. I/K represents fixed asset investment over tangible fixed assets; CFK, cash flow over tangible fixed assets; asset growth, the percentage growth of tangible fixed assets; coverage ratio net income over total interest payments; liquidity, current assets net of current liabilities over total assets; percentage growth of total sales.

Table 3.B.8: Means of key variables with different foreign ownership

	$fcap = 0\%$	$0\% < fcap \leq 25\%$	$25\% < fcap \leq 50\%$	$50\% < fcap \leq 75\%$	$75\% < fcap < 100\%$	$fcap = 100\%$
I/K	12.19	12.38	11.74	10.99	13.07	13.27
CFK	37.39	35.14	42.09	44.29	44.77	45.26
asset growth	10.96	9.4	8.41	6.92	10.25	10.5
leverage ratio	61.09	58.95	57.38	50.86	50.06	50.04
tangibility	37.43	32.89	30.63	32.23	32.31	32.41
liquidity	3.24	5.69	10	14.63	13.66	13.67
sales growth	12.43	10.08	9.83	9.9	13.13	13.31

Notes: This table reports the means of difference groups. $fcap$ is the percentage of shares held by foreign investors. I/K represents fixed asset investment over tangible fixed assets; CFK, cash flow over tangible fixed assets; asset growth, the percentage growth of tangible fixed assets; coverage ratio net income over total interest payments; liquidity, current assets net of current liabilities over total assets; percentage growth of total sales.

3.C Variable construction

Tangible fixed assets: total fixed assets minus intangible assets

Real sales: total sales of goods and render of services deflated by provincial price index

sales growth: difference between logarithm of current real sales and logarithm of lagged real sales

Cash flow: net cash flow plus depreciation

Fixed investment: difference between the book value of tangible fixed assets

Tangibility: the ratio of tangible fixed assets to total assets

Liquidity: the ratio of liquid assets to tangible fixed assets

Expdum: export dummy equal to one when the firm export

TFP: total factor productivity estimated using the Levinsohn and Petrin (2003) method, applied separately to different industrial groups. The levpet Stata command was used in estimation.

Age: current year – firm's year of establishment.

Deflators: taken from the China Statistical Yearbook (various issues), which are published by the National Bureau of Sta- tistics of China. The provincial capital goods deflator was used to deflate the capital stock, and the provincial producer price indices (PPI) for manufactured goods to deflate other variables.

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Chapter 4

Investment under Uncertainty and Ambiguity Aversion

4.1 Introduction

The discussion on investment-cash flow sensitivities is popular in the decades since Fazzari et al. (1988) suggested that high investment-cash flow sensitivity explains capital market imperfections and indicates financial constraints. After that, a number of studies presented different arguments on whether or not the investment-cash flow sensitivity is an ideal indicator of financial constraints.

Recent studies show some facts that make us doubt the monotonic relationship between investment and cash flow. Ding et al. (2013) use a very large dataset from 2000-2007. They show that in China, fixed investment is less than 20% of total cash flow. Guariglia (2008) summarise 124,590 annual observations on 24,184 companies in UK from 1996-2003. She shows that not only in China, UK firms only use 35% of their total cash flow for investment. When it comes to US, Hovakimian and Titman (2006) use a sample covering manufacturing firms listed on the NYSE, AMEX, and NASDAQ from 1977-2000. On average, firm investment expenditure do not exceed 60% of cash flow.

Although they are only summary statistics, these numbers point out that firm average cash flow is far larger than fixed investment (especially in China). For most of the firms, even if they face a large cash flow shock (maybe half their cash flow), they can still finance their investment internally. So there is a question, are firms (especially in China) truly constrained? If not, how do we interpret the investment cash flow sensitivity?

Given the questions and conflicts above, we want to suggest a new channel of explaining investment cash flow sensitivity under the framework of uncertainty. To be more specific, we reconcile sensitivity and uncertainty: uncertainty (ambiguity) aversion (Ilut and Schneider, 2012) make unconstrained firms look constrained. Uncertainty contributes to precautionary savings which will reduce fixed investment. Riskier firms will hold more cash and their investment decisions will be largely based on cash flow. With this mechanism, we could explain why firms are not constrained but still sensitive to cash flow.

Many studies discuss how uncertainty can affect investment. Generally speaking, most studies believe uncertainty has a negative effect on investment and from a macro level, it can negatively affect economic growth. Intuitively, Bloom (2014) find that during recession, uncertainty will rise. Bloom (2009) finds that uncertainty will increase the real options, which will make firms less likely to invest or hire. There are also many empirical studies with firm-level data. For example, Bloom et al. (2007) use U.K. manufacturing firm data from 1972 to 1991. The result is consistent with real option theory. The 'real option' theory is also proved by Gilchrist et al. (2014) with U.S. non-financial firms from 1973-2012. They find that 'real option' and financial distortions have a joint effect on investment. More specifically, without financial distortion 'real option' seems less significant. There are also some other studies. For example, Bo and Lensink (2005) analyse the Dutch non financial firms, from 1985 to 1996. They find that the relationship between investment and uncertainty is an inverted U curve.

The model we use is a dynamic structural model of firm value maximization. Three types of adjustment costs are included, partial irreversibility quadratic adjustment costs and fixed cost. In the following sections we will test our hypothesis from both a theoretical and empirical perspective. Irreversibility is the key of uncertainty and quadratic adjustment costs are most commonly used in previous studies. In line with Bloom et al. (2007), we maximize firms' value with a Bellman equation and we solve the maximization problem with the numerical method. For simplicity we use only one type of capital suggested by Abel and Eberly (1999). Demand shocks are assumed to be the only source of uncertainty, which follow an augmented geometric random walk. More importantly we include ambiguity aversion hypothesis in our model. The hypothesis suggests that firms are averse to uncertainty. So, they will behave as they are going to face the worst outcomes in future. Practically, we build a ceiling of investment. Firms will be safe if their fixed investment is lower than the ceiling, but will be in danger if it exceeds.

We then simulate the model with our theoretical framework. We want to find some implications from our model.

Our empirical specification is designed to test the theoretical hypotheses. We firstly use our simulated data to provide some theoretical implications. We simulate 10,000 firms over 15 years. There are three main findings: First, there is a nonlinear relationship between investment and demand shocks: we find a negative relationship between investment and quadratic demand growth. Second, uncertainty has a negative impact on investment and decreasing investment sensitivity to demand shocks. Third, uncertainty can increase the investment-cash flow sensitivity.

Then we apply the empirical data. The estimation method we use is the system generalised method of moments (GMM). We divide the samples to different levels of financing constraints in order to find how much uncertainty can affect the response of investment to demand shocks. The purpose is to highlight how uncertainty amplifies the effect of financing constrains and plays a role as a decelerator.

We use NBS (National Bureau of Statistics) data over 1998-2007, which covers more than 600,000 firms containing 2,000,000 observations across 31 provinces. It is ideal to show the features of China's economy. Since the ratio of investment over cash flow is very low in China, it would be more interesting to find out why. More importantly, the dataset contains information of ownership, which is an important indicator of financial constraints, especially for a transition economy. The results suggest that the explanatory power of investment opportunities decrease when uncertainty increase. This not only shows that uncertainty has a negative impact on investment, but also proves the existence of ambiguity aversion. When uncertainty is high, firms will use cash flow, rather than investment opportunity, as an indicator of investment to protect themselves from the worst possible outcome. The findings suggest that there is an 'ambiguity aversion channel' that makes firms sensitive to cash flow.

The rest of the chapter is organised as follows. Section 2 will theoretically introduce how investment responds to investment opportunities under uncertainty and ambiguity aversion. Section 3, we test our theoretical hypotheses with simulated data. Section 4, we will introduce the empirical data we use. Section 5, presents our regressions and discuss empirical results, and section 6 is our conclusion.

4.2 The model

According to the assumptions made by Abel and Eberly (1999), Bloom et al. (2007) and Bloom (2009), a firm's operating cash flow is $X_t^{\gamma} K_t^{1-\gamma}$. X_t is a demand factor and it is the only source of uncertainty.

4.2.1 Uncertainty, adjustment costs and structural dynamic model

If we take adjustment costs into consideration, a firm net profit is:

$$\Pi_t = X_t^{\gamma} K_t^{1-\gamma} - G(I_t, K_t) - I_t \tag{4.1}$$

, where $G(I_t, K_t)$ is adjustment costs, γ is the output elasticities of capital, I_t is fixed investment, which is defined as

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

. δ is a constant depreciation rate, and the adjustment costs comprises two components quadratic adjustment costs and partial irreversibility:

$$G(I_t, K_t) = b_q \left(\frac{I_t}{K_t}\right)^2 K_t + b_f X_t^{\gamma} K_t^{1-\gamma} 1_{[I_t \neq 0]} - b_i I_t 1_{[I_t < 0]} \tag{4.2}$$

, where b_q, b_f and b_i are the parameters of quadratic adjustment costs, fixed costs and irreversibility respectively. Define $x_t \equiv \ln X_t$

$$x_t = x_0 + \mu t + z_t \tag{4.3}$$

$$\varepsilon_t \overset{i.i.d}{\sim} N(0, \sigma^2)$$

So the dynamic optimization problem could be denoted as:

$$K_t V(X_t^*, \sigma_t) = \max_{I_t} K_t \{\Pi_t(X_t^*, I_t^*) + \frac{\beta K_{t+1}}{K_t} E[V(X_{t+1}^*, \sigma_{t+1})]\}$$

$$\frac{K_{t+1}}{K_t} = \frac{K_t(1-\delta) + I_t}{K_t} \approx (1-\delta)(1+I_t^*) \tag{4.4}$$

where $X_t^* = \frac{X_t}{K_t}, I_t^* = \frac{I_t}{K_t}$.

4.2.2 Ambiguity aversion hypothesis

Rational expectation assumption in economics suggests that agents will think as econometrician. An increase in risk will increase the variance of shocks. However, ambiguity is different from risk. Risk means all agents know the probabilities of outcomes, but ambiguity means that agents have no information of the probabilities. Ellsberg (1961) find an behavioural distinction between risk and ambiguity. People prefer to know the odds. Gilboa and Schmeidler (1989) then distinguish tastes (ambiguity aversion) from beliefs (ambiguity). They suggest that decision makers have multiple priors. Every prior is assessed with its minimal expected utility. Then the minimum of utility is taken over all priors.

Ilut and Schneider (2012) apply the ambiguity aversion theory. An increase in uncertainty will lower confidence, and ambiguity aversion suggests that a loss of confidence agents act as if they are going to face the worst outcomes. The worst outcomes could be captured by using 'a worst case probability drawn from a set of multiple beliefs'. An increase of uncertainty could be captured by an increase in the width of the interval. The 'worst case' mean becomes worse. Because of ambiguity aversion, firms will not choose to invest over 'worst case mean'.

For example, if there is no uncertainty ($\sigma_t = 0$), the 'worst case' mean is the mean value of cash flow $E(X_t)_t^{\gamma} K_t^{1-\gamma}$. As such, when there is no external finance, investment ceiling is its cash flow. But if $\sigma_t \neq 0$, firms should take uncertainty into account. Firms need to estimate negative demand shocks in the following period. Using expected net cash flow as the ceiling of their investment decisions is too risky. If the negative demand shock is very large, then firms cannot use their internal funds to cover their investment, they are very likely to become bankrupt.

To solve this problem we use the 'maxmin' idea suggested by Ilut and Schneider (2014). As external finance is the second choice for firms, firms prefer to use internal finance to cover their investment. In addition, in China cash flow is far larger than investment, most firms can use their internal finance to cover investment. If firms are ambiguity averse, they will consider the 'worst case' of their revenue. Thus, they will not choose to invest more than the 'worst case' of their revenue. We can call this as investment ceiling. If investment exceeds this ceiling, firms will face the risk of bankruptcy.

To apply Ilut and Schneider's (2014) 'max-min' idea, we suggest that firms can collect demand information from history, which could be denoted as a vector of demand growths $\mu^{t-1} = (\mu_1, ..., \mu_{t-1})$. Firms can observe demand before t, but cannot observe μ^t.

So the Bellman equation could be written as:

$$V_t = \max_{I_t} \{ \min_{\mu^p \in P(\mu^{t-1})} E^p[(X_t(\mu^{t-1}, \mu_t)^{\gamma} K_t^{1-\gamma}] - I_t - G(I_t, K_t) \\ + \beta E[V(X_{t+1}, K_{t+1}, \sigma_{t+1}; \mu^{t-1}, \mu_t, \mu_{t+1})] \}.$$

where $P(\mu^{t-1})$ is a set of demand growth in history. Since we know that demand growth $\mu_t = \mu + \sigma_t R_t$, and R_t follows a standard normal distribution. Under the given belief set P, R_t has a mean denoted as R_t^p which lies in $[-a, a]$. If the firm-level demand uncertainty is σ_t, μ_t lies in a support $[\mu - a\sigma_t, \mu + a\sigma_t]$. Given 'worst case' belief p_0, we have $R_t^p = R_t^{p_0}$, and $\mu_t^{p_0} = \mu - a\sigma_t$.

If the firms are averse to uncertainty, they will use the cash flow of the 'worst case' as the ceiling of investment. That is to say, investment is constrained by the 'worst case'.

$$I_t + G(I_t, K_t) < X_t(\mu_t^{p_0})^\gamma K_t^{1-\gamma}$$

As in the equation above, we find a way to link investment with cash flow (or cash flow). It shows that investment could still be sensitive to cash flow, when the firm is not constrained and after investment opportunities are properly measured.

4.3 Model simulation

The firms' optimization problem is solved with value function iteration. We follow the numerical analysis process suggested by Adda and Cooper (2003), and Bloom (2009). We firstly maximise the value function without considering financial constraints. Generally, there are three steps:

1. discretizing the state variables X_t^* and $\frac{K_{t+1}}{K_t}$ into 100 grids each. We also creates five uncertainty levels from 0.1 to 0.5.

2. start with a guess for the true value function $v1$.(We guess initial $v1$ to be 0). Use it on the Bellman equation, and we could get $v2$.

3. update $v1 = v2$ and put $v1$ on Bellman equation again. We keep this process running until $v1$ converges to a fixed value. With the converged value we could find out the optimal choice of investment.

4.3.1 Calibration and aggregation

Data are simulated according to numerical results. We set some starting values based on Bloom et al. (2007), and Wu (2009). We impose $\gamma = 0.25$. b_q and b_i are both 0.5. Fixed cost b_f is 0.05. Discount rate β is 0.91 and depreciation rate δ is 0.1. If the firm is averse to ambiguity, $a = -1.96$. This suggests that if the firm has no external finance, under 95% confidence level, it will survive from uncertainty. $(1+\mu)^2$ is 1.04. The data is simulated monthly. We have the ergodic distributions after the simulation runs for 10 years (120 months). [1]

4.3.2 Investigating the theoretical implications

Figure 1 and 2 presents the lowess-smoothed plots of our simulated investment and demand growth according the the policy function [2]. We split the sample into three groups, namely low, median and high uncertainty. Each group accounts for roughly one third of total observations.

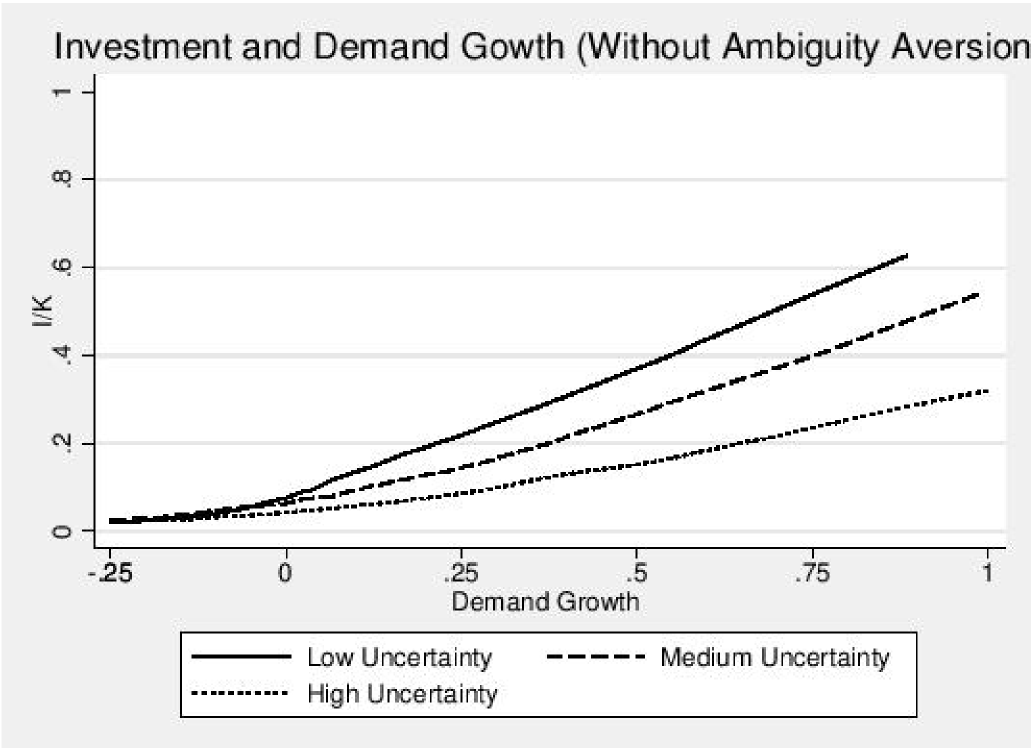

Figure 4.1: Investment and demand shocks without ambiguity aversion

Figure (4.1) shows that investment is growing along with the increase of demand. The result is very close to Bloom et al. (2007). Bloom et al. (2007) argue that uncertainty has a negative impact on investment. One finding is that uncertainty could decrease the sensitivity of investment to demand growth. Another finding is that there is a positive non-linear impact of demand growth on investment. Then we suggest

[1]To be consistent with our empirical dataset, when we simulate data, we impose a restriction that current investment will not increase firms' capital simultaneously. Firms' investment and capital stocks are summed by the beginning of next year.

[2]Lowess smoothing is a smoothing method which carrys out a locally weighted regression and display the graph. The command of lowess is available in Stata

another channel of the negative effect of uncertainty and the non-linear relationship is presented in Figure (4.2). The result shows a dramatic different pattern when com-

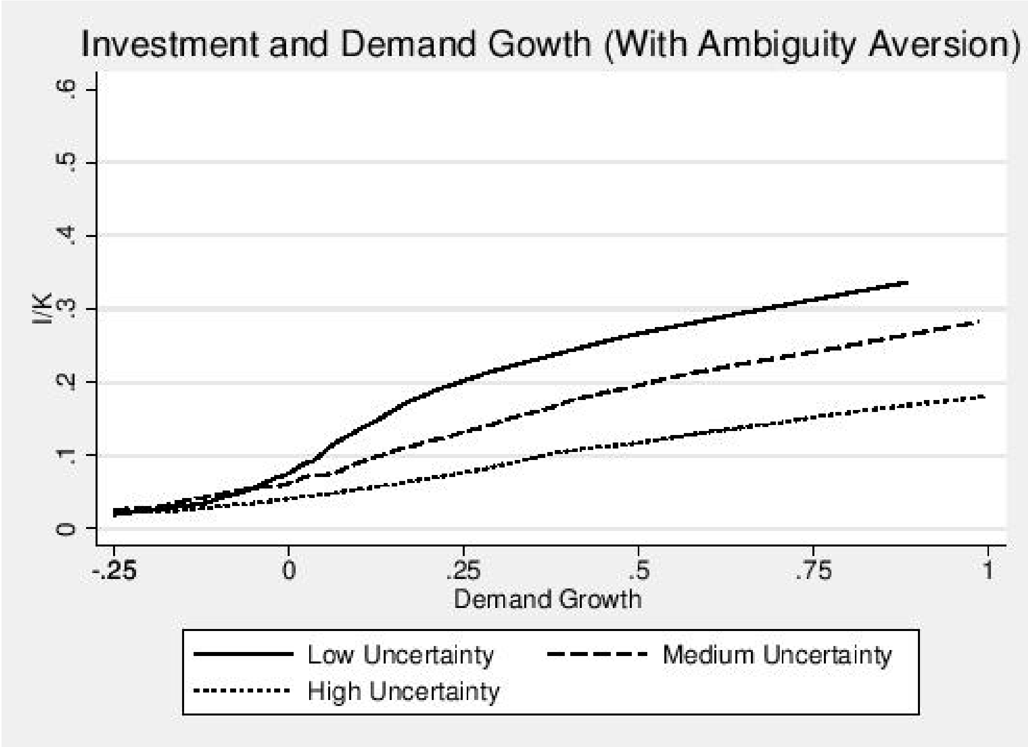

Figure 4.2: Investment and demand shocks ambiguity aversion

pared with Figure(4.1). Both Figure(4.1) and Figure (4.2) show that firms facing low uncertainty invest more than 'high uncertainty firms'. However, we find that when demand growth exceeds 25%, investment with ambiguity aversion show a weaker response to the growth. There is a negative non-linear impact of demand growth on investment. When the growth is between 0 and 25%, for 'low uncertainty firms', the sensitivity of investment to demand growth is around 4 times higher than high uncertainty firms. When demand growth is higher than 25%, low and high uncertainty firms show almost the same slope. This is because, when firms are averse to uncertainty, high investment opportunities are not their only factor to consider. They are also concerned about the 'worst case' in future. Thus, they will invest after they are sure that their firms are going to survive in future.

4.4 Empirical specification

As predicted by the model, when there is no ambiguity aversion, a firm's investment shows a convex response to demand shocks, However, if there is ambiguity aversion, the relationship between investment and demand shocks is concave. To precisely link the model to empirical tests, we start our estimation from the most basic Q model that investment is only decided by investment opportunities.

$$I_{i,t}/K_{i,t-1} = a_0 + a_1\Delta y_{i,t} + a_2\Delta y_{i,t}^2 + v_i + v_t + v_j + v_{j,t} + e_{i,t} \tag{4.5}$$

where $I_{i,t}/K_{i,t-1}$ is firm i's investment at time t against capital stock at $t-1$[3]. In our theoretical framework, X is a firm's demand shock. However, in real firm-level data sets we observe proxies for demand growth as firm sales growth. We denote real sales of firm i at time t as $Y_{i,t}$. Sales growth is the first difference of $\log(Y_{i,t})$, which is denoted as $\Delta y_{i,t}$. Therefore, we use sales growth, the only observable proxy for demand growth, to measure investment opportunities. In addition, we find that there are non-linear relationships between investment and demand growth. So, we also include a quadratic term of demand growth, $\Delta y_{i,t}^2$, as additional information of investment opportunities. This is used to control the convex or concave relationships between investment and demand shocks as we considered in our theoretical model. More specifically, the positive coefficient of the quadratic term $\Delta y_{i,t}^2$ indicates a convex relationship between investment and demand shocks. This is consistent with Figure 4.1. If the quadratic term is negative, the relationship between investment and demand shocks is concave. This is consistent with Figure 4.2 and appears the features of ambiguity aversion.

[3] In chapter 3 we use investment and cash flow normalized by contemporaneous capital stock, as the measurement of investment. The reasons are as follows. In Gilchrist and Himmilburg (1998) they use panel VAR model. The penal VAR is also a panel time series method, which uses lagged values to forecast future values. Using investment and cash flow normalized by lagged capital stock can automatically remove one-year observations. To remove the fixed effects, we use first difference method. Additional one-year observations removed. Then I use lagged variables to forecast fundamental q. Variables lagged once and twice are used as regressors. Then I want to estimate the response of investment to forecasted q. With panel VAR method 2 lags are required. Finally, we need firms to have at least 6-year observations. There is only a small proportion of firms satisfy this restriction. So, there are two benefits of using investment and cash flow normalized by contemporaneous capital stock in chapter 3. First, it can help to keep more observations. Second, it allows testing impulse response in a longer period. In chapter 4, we use investment and cash flow normalized by lagged capital stock. The reason is because in economic theory: $I_t = K_t - (1-\delta)K_{t-1}$, where δ is depreciation rate. In the neoclassical model, is the capital stock at the beginning of the year. However, in real world, firms will report their capital stocks by the end of the year. In addition, current investment is not used for production immediately. Thus, in order to be consistent with our theory, we use I_t/K_{t-1} as the measurement of investment.

There are five types of error terms: (1) firm specific time invariant effects (v_i); (2) time specific effects (v_t); (3) industry specific effects (v_j); (4) time specific and industry specific effects (v_{jt}), which are used to capture industry specific business cycles. (5) an idiosyncratic error (e_{it}).

We will also take cash flow into consideration. Beside the evidence shown by FHP (1988), we tend to show a new channel to explain the investment cash flow sensitivity. In our theoretical framework, we predict that when there is ambiguity aversion, managers will behave as if they are going to face the 'worst outcomes'. Thus, there is a ceiling of investment and firms may choose to invest projects according to their cash flow. Empirically, we add cash flow term to the regression and estimate the following equation:

$$I_{i,t}/K_{i,t-1} = a_0 + a_1\Delta y_{i,t} + a_2\Delta y_{i,t}^2 + a_3 CF_{i,t}/K_{i,t-1} + v_i + v_t + v_j + v_{j,t} + e_{i,t} \quad (4.6)$$

where $CF_{i,t}/K_{i,t-1}$ is the cash flow term, which is defined as current cash flow over lagged capital stocks ($Cashflow_{i,t}/K_{i,t-1}$).

Finally, we want to check how uncertainty affects investment cash flow sensitivity. According to our model, we would expect to observe negative relationship between investment and uncertainty. Then we include uncertainty in our model. According to Bloom et al. (2007), uncertainty is captured from two perspectives. The first is uncertainty itself (σ_{it}), measured by the standard deviation of $\varepsilon_{i,t}$ in Equation (4.3). And the other is an interaction term $\sigma_{\varepsilon,it} * \Delta y_{i,t}$. This variable is used to test how uncertainty will affect investment response to demand shocks. In our theoretical framework, we expected that firm investment decisions with ambiguity aversion show negative response to uncertainty. Then we could write our specification as:

$$I_{i,t}/K_{i,t-1} = a_0 + a_1\Delta y_{i,t} + a_2\Delta y_{i,t}^2 + a_3\sigma_{\varepsilon,it} + a_4\sigma_{\varepsilon,it} * \Delta y_{i,t} + a_5 CF_{i,t}/K_{i,t-1} + v_i + v_t + v_j + v_{j,t} + e_{i,t} \quad (4.7)$$

One of our main purpose of this chapter is to find the link between investment and cash flow. When there is no financing constraint and managers are averse to uncertain cash flow shortfall, as we predicted in the model, investment would be sensitive to cash flow. In short, we want to test that uncertainty is a link of investment and cash flow. So we expect that the higher uncertainty can lead to higher investment-cash flow sensitivity. We apply the same method as used above. We will include a interaction term of uncertainty and cash flow. $\sigma_{\varepsilon,it} * CF_{i,t}/K_{i,t-1}$.

$$I_{i,t}/K_{i,t-1} = a_0 + a_1\Delta y_{i,t} + a_2\Delta y_{i,t}^2 + a_3\sigma_{\varepsilon,it} + a_4\sigma_{\varepsilon,it} * \Delta y_{i,t} + a_5 CF_{i,t}/K_{i,t-1} + a_6\sigma_{\varepsilon,it} * CF_{i,t}/K_{i,t-1} + v_i + v_t + vj + v_{j,t} + e_{i,t} \tag{4.8}$$

4.5 Estimation results of simulated data

To make a deeper investigation on the properties of investment and ambiguity aversion, we estimate the two panels simulated above.

Table 4.1: Estimation on simulated data

	(1)	(2)	(3)	(4)	(5)	(6)
Ambiguity Aversion	no	yes	no	yes	no	yes
$\Delta y_{i,t}$	0.161***	0.154***	0.467***	0.410***	0.476***	0.412***
	(0.00184)	(0.00146)	(0.00588)	(0.00426)	(0.00588)	(0.00388)
$\Delta y_{i,t}^2$	0.145***	-0.00938**	0.263***	0.0981***	0.303***	0.108***
	(0.00888)	(0.00440)	(0.00925)	(0.00451)	(0.00958)	(0.00358)
$\sigma_{\varepsilon,it}$			-0.205***	-0.193***	-0.168***	-0.144***
			(0.00470)	(0.00398)	(0.00400)	(0.00322)
$\sigma_{\varepsilon,it} * \Delta y_{i,t}$			-0.901***	-0.759***	-0.982***	-0.835***
			(0.0151)	(0.0114)	(0.0144)	(0.00964)
$CF_{i,t}/K_{i,t-1}$					0.754***	0.933***
					(0.00961)	(0.00816)
Constant	0.0793***	0.0771***	0.134***	0.128***	-0.0901***	-0.149***
	(0.000614)	(0.000523)	(0.00123)	(0.00108)	(0.00309)	(0.00266)
Observations	140,000	140,000	140,000	140,000	140,000	140,000
R-squared	0.233	0.214	0.293	0.286	0.362	0.453

Notes: this table reports results estimated with simulated data by OLS method. Columns (1),(3), and (5) estimated the sample without ambiguity aversion. Columns (2),(4), and (6) estimated the sample with ambiguity aversion.$\Delta y_{i,t}$ is demand growth.$\Delta y_{i,t}^2$ is quadratic demand growth. $\sigma_{\varepsilon,it}$ is uncertainty of demand shocks. $CF_{i,t}/K_{i,t-1}$ is cash flow over lagged tangible fixed asset.

Table 4.1 reports the estimation results from Equation (4.5 and 4.7). Columns (1) (3) and (5) reports the sample without ambiguity aversion and Columns (2) (4) (6) are the results estimated with ambiguity aversion sample. From column (1) and (2) we find that for no ambiguity aversion firms, the coefficient of the quadratic term is positive, which is consistent with Bloom et al. (2007). For the firms averse to uncertainty, the coefficient of demand growth is very close to the coefficient estimated with no ambiguity aversion sample, but in terms of the quadratic term, the coefficient is negative. This is consistent with our non-parametric plots in Figure (4.2). This suggests that ambiguity aversion can make investment opportunities less important. Column (3) and (4) reports the estimation results of Equation (4.7). We find that after we control uncertainty and the interaction term, coefficients of demand shocks increase dramatically, from 0.161 to 0.467 and from 0.154 to 0.410. In addition we find that the coefficients of the quadratic term increase as well. This suggests that uncertainty is one key to explain the negative effect of the quadratic term. Uncertainty can effect investment by weakening the importance of investment opportunities. Column (5) and (6) show that cash flow has a large impact on firm investment. The cash flow coefficients for no aversion and aversion groups are 0.754 and 0.933 respectively. This suggests that when cash flow increases 1%, investment will increase 0.75% and 0.93% percent. This investment-cash flow sensitivity is higher than most of previous influential studies (for example, FHP (1988) suggest that this number is between 0.22 and 0.37. Kaplan and Zingales (1997) although hold different argument with FHP(1988), they shows that the sensitivities are around 0.16 to 0.78). The reason is because in our simulated data we define cash flow as $\pi_t = X_t^{\gamma} K_t^{1-\gamma}$. Cash flow is then correlated with investment opportunities. In addition, our simulated cash flow is a non-negative variable and less volatile than investment. So, a small shock of cash flow can cause a large impact on investment. This high sensitivity could also be found in Riddick and Whited (2009).

To find out how uncertainty affect investment-cash flow sensitivity, we introduce another interaction term in our empirical specification, $\sigma_{\varepsilon,it} * CF_{i,t}/K_{i,t-1}$, as specified in Equation (4.8).

The result is shown in Table (4.2). We find that the interaction term of uncertainty and cash flow has positive impacts on cash flow. It suggest that the growth of uncertainty will increase the investment sensitivity to cash flow, but decrease the sensitivity investment opportunities. For the ambiguity averse firms, there is a substitution effect between investment opportunities and cash flow. When uncertainty is low, firms concern more about investment opportunities, but when uncertainty is high, firm investment base more on cash flow. This explains why firms are not financially constrained but still show high investment cash flow sensitivity. This also explains why firms are sensitive to cash flow after investment opportunities are properly measured. This finding is consistent with our hypothesis: uncertainty can make unconstrained firms behave as if they are constrained.

Table 4.2: Uncertainty and investment cash flow sensitivity with simulated data

	(1)	(2)
Ambiguity Aversion	no	yes
$\Delta y_{i,t}$	0.467***	0.413***
	(0.00594)	(0.00367)
$\Delta y^2_{i,t}$	0.0730***	-0.109***
	(0.0170)	(0.00598)
$\sigma_{\varepsilon,it}$	-0.698***	-0.561***
	(0.0234)	(0.0195)
$\sigma_{\varepsilon,it} * \Delta y_{i,t}$	-0.840***	-0.708***
	(0.0147)	(0.00902)
$CF_{i,t}/K_{i,t-1}$	0.125***	0.443***
	(0.0282)	(0.0248)
$\sigma_{\varepsilon,it} * CF_{i,t}/K_{i,t-1}$	1.769***	1.372***
	(0.0817)	(0.0695)
Observations	140,000	140,000
R-squared	0.377	0.470

Notes: $\Delta y_{i,t}$ is demand growth.$\Delta y^2_{i,t}$ is quadratic demand growth. $\sigma_{\varepsilon,it}$ is uncertainty of demand shocks. $CF_{i,t}/K_{i,t-1}$ is cash flow over lagged tangible fixed assets.

4.6 Data and summary statistics

4.6.1 Data

The firm-level data we use comes from annual surveys conducted by National Bureau of Statistics (NBS). The data is collected annually on industrial firms which include all of state owned firms and non-state owned firms with sale scale above 5 million RMB(usually called as 'above scale' firms), from 1998 to 2007. The industries of these firms are mining, manufacturing and public utilities. The original dataset contains more than 600,000 firms and 2,000,000 observations across 31 provinces[4].

[4]Please find more data descriptions in the Chapter 3, section 3.4.

4.6.2 Summary statistics

Table 4.3 shows the summary statistics of key variables. We follow the method suggest by Guariglia et al (2011) and consistent with the method introduced in Chapter 3. Our original dataset contains 2,205,730 observations. We deleted observations with negative sales, as well as observations with negative total assets minus total fixed assets, total assets minus liquid assets, and accumulated depreciation minus current depreciation. There are 2,960 observations dropped. We have 2,202,770 observations left. We cut 1 percent tails of the key variables to control for the potential influence of outliers [5]. Finally we have 2,075,843 observations. The observation numbers of SOEs, private, foreign and collective firms are: 246,427, 1,251,545, 279,135, 196,690 respectively. 73,958 observations have no major ownerships and 28,145 observations have no ownership information.

Table 4.3: Summary statistics for key variables (outliers dropped)

	full sample	SOEs	Private	Foreign	Collective	Diff(SOEs & Private)
$I_{i,t}/K_{i,t-1}$	27.0	13.1	31.0	24.5	22.3	0.00***
	(6.24)	(1.29)	(8.06)	(6.92)	(4.46)	
	{0.683}	{0.503}	{0.731}	{0.606}	{0.636}	
$CF_{i,t}/K_{i,t-1}$	50.0	11.7	53.4	56.6	54.7	0.00***
	(21.5)	(37.0)	(24.2)	(24.3)	(21.2)	
	{1.05}	{0.578}	{1.04}	{1.20}	{1.15}	
Sales growth	11.8	-1.59	15.4	12.2	5.28	0.00***
	(11.0)	(1.71)	(13.6)	(11.2)	(6.79)	
	{0.454}	{0.501}	{0.450}	{0.430}	{0.436}	
Firm Size	9.85	10.1	9.68	10.5	9.53	0.00***
	(9.68)	(10.0)	(9.51)	(10.3)	(9.48)	
	{ 1.44}	{1.94}	{1.33}	{1.37}	{1.23}	
Observations	2,075,843	246,427	1,251,545	279,135	196,690	

Notes: This table reports sample means, medians in round brackets, and standard deviations in curly brackets. $I_{i,t}/K_{i,t-1}$ represents fixed asset investment over lagged tangible fixed assets; $CF_{i,t}/K_{i,t-1}$, cash flow over lagged tangible fixed assets; Firm Size is natural logarithm of total asset. All the means and medians in the table are percentages except size. Diff is the p-value associated with the t-test for differences in means of corresponding variables between SOEs and private firms. *** indicates significance at the 1% level.

[5]The variables are: current investment over lagged capital, current cash flow over lagged capital ratio, and sales growth.

Table 4.3 reports the means, median and standard deviations of key variables. SOEs invest less than other firms on average. Private firms exhibit the highest investment rate (31%) while the SOEs invest lowest (13.1%) [6]. Besides, private and foreign firms also have the highest cash flow level. Their cash flow to tangible fixed assets ratios are 53.4% and 56.6% respectively. The sales growth of private firms is also higher than SOEs. The sales growth of SOEs is negative, -1.59% and private firms' average sales growth is 15.4%. This is consistent with their high cash flow level. In terms of firm size, SOEs are larger than private firms. On average foreign firms are largest in our sample. In general, we find that private firms are smaller, but invest more and grow faster. In Guariglia (2008), size is an indicator of asymmetric information. Larger firms are less likely to face financing constraint problem. State owned firms are not constrained, but they invest less and grow slower.

Table 4.4: Correlation coefficients of key variables

	$I_{i,t}/K_{i,t-1}$	$CF_{i,t}/K_{i,t-1}$	Sales growth	$I_{i,t-1}/K_{i,t-2}$	$CF_{i,t-1}/K_{i,t-1}$
$I_{i,t}/K_{i,t-1}$	1.0000				
$CF_{i,t}/K_{i,t-1}$	0.2550	1.0000			
Sales growth	0.1354	0.1856	1.0000		
$I_{i,t-1}/K_{i,t-2}$	-0.0170	0.0077	0.0644	1.0000	
$CF_{i,t-1}/K_{i,t-2}$	0.1368	0.5926	0.0175	0.2705	1.0000

Table 4.4 reports the correlation coefficients of key variables. We find that investment ($I_{i,t}/K_{i,t-1}$) is positively correlated with cash flow ($CF_{i,t}/K_{i,t-1}$) and sales growth. However, the correlation between investment and lagged investment is very low. This finding is consistent with Gomes (2001), that firm investment is lumpy, the serial correlation of investment is low. In addition, we also check the serial correlation of cash flows. The correlation is 0.59, which is very high. In addition we find that the correla-

[6]The mean of $I_{i,t}/K_{i,t}$ in table 3.4 is 8.73% but the mean of $I_{i,t}/K_{i,t-1}$ in table 4.3 is 27.0%. There is a very large difference. We checked our dataset, and we compared the distributions of these two different measurement. We find that below 75 percentiles the two measurements are very close. The main difference is that $I_{i,t}/K_{i,t-1}$ is more positively skewed than $I_{i,t}/K_{i,t}$. This is the key reason that why these two measurements have different means. Above 90 percentiles the average values of $I_{i,t}/K_{i,t}$ and $I_{i,t}/K_{i,t-1}$ are 58.2% and 346% respectively. This is because $K_{i,t} = K_{i,t-1} - depreciation_{i,t} + I_{i,t}$. When investment is very large, $\frac{I_{i,t}}{K_{i,t}} = I_t/(K_{t-1} - depreciation_{i,t} + I_{i,t})$, and $\lim_{I\to\infty}(I_{i,t}/K_{i,t}) = 1$, subject to the condition $K_{t-1} - depreciation_{i,t} \geq 0$. However, in terms of $I_{i,t}/K_{i,t-1}$, $\lim_{I\to\infty}(I_{i,t}/K_{i,t-1}) = \infty$.

tion between current cash flow $CF_{i,t}/K_{i,t-1}$ and lagged investment $I_{i,t-1}/K_{i,t-2}$ is also very low (only 0.0077). However, the correlation between $I_{i,t}/K_{i,t-1}$ and $CF_{i,t-1}/K_{i,t-2}$ is much larger (0.1368). This reveals some causal relationship between investment and cash flow; that cash flow can support investment, but investment is less likely to increase cash flow. This table can help us to understand a basic relationship between investment, cash flow and sales growth.

4.7 Empirical results with company data

We then estimate our baseline specification from Equation (4.5 and 4.7). The main aim is to test if firms in China are ambiguity averse. We compare the empirical results estimated with simulated and real data to find the consistency between the results. If firms are averse to ambiguity, there should be three key features: first, the quadratic demand term should have a negative impact on investment. Second, the interaction term of demand shock and uncertainty should have a negative impact on investment. In addition, we expect to find that under ambiguity aversion, uncertainty has a non-negative impact on investment-cash flow sensitivity. That is the channel we use to explain why firms have very high cash flows and are unconstrained but are still sensitive to cash flow. Empirically we capture demand shocks with sales growth, this is consistent with Bloom et al. (2007).

We use system GMM method to test our baseline specifications. This is because our data has a very large number of N but small T. It takes into account unobserved firm heterogeneity and possible endogeneity and mismeasurement problems of the regressors. By adding the original equation in levels to the system and exploiting these additional moment conditions, Arellano and Bover (1995) and Blundell and Bond (1998) found a dramatic improvement in efficiency and a significant reduction in finite sample bias compared with first-differenced GMM. We instrument the right hand side variable by two lags in level equation and three or more lags in differenced equation.

In the presence of serial correlation of order n in the differenced residuals, the instrument set needs to be restricted to lags n+1 and longer for the transformed equation and lag n for the level equation (Roodman, 2009). We initially use two lags of all regressors as instruments in the differenced equation. However, since all our models generally fail the test for second-order autocorrelation of the differenced residuals, levels of all regressors lagged three times are used as instruments in the first-differenced equations. First-differenced variables lagged twice are used as additional instruments in the level equations.

4.7.1 Nonlinear relationship between investment and demand shocks

Table 4.5: Empirical estimation with NBS Data: investment and sales growth

VARIABLES	(1) full sample	(2) private	(3) SOE	(4) foreign	(5) collective
Sales growth	1.011***	1.066***	0.298***	0.499***	0.129
	(0.103)	(0.151)	(0.0947)	(0.170)	(0.257)
Sales growth squared	-0.505**	-0.141	-0.168	-0.000976	-0.0843
	(0.213)	(0.266)	(0.221)	(0.263)	(0.430)
Observations	1,382,894	843,959	140,235	209,166	133,590
Number of id	417,897	269,253	40,067	52,375	40,479
m1	0	0	0	0	0
m3	0.539	0.902	0.676	0.993	0.0100
Hansen test p-value	0	0.000763	0.181	5.72e-05	0.0846

Notes: This table reports the estimates obtained with system GMM estimator. The instrument sets are all the regressors lagged 3 times and longer for the first differenced equation and lagged twice for the level equation. Time dummies, industry dummies, and time interacted with industry dummies are included. Figures in parentheses are asymptotically standard errors. m1 and m3 are p values of AR(1) and AR(3) tests.

The results of Equation 4.5 are reported in Table 4.5. We find that private firms show highest sensitivity to sales growth and collective firms show lowest sensitivity. We also find this result in chapter 3 that investment efficiency of SOEs is lower than private firms. In the absence of a perfect capital market , a variety of frictions (such as information asymmetries, agency problems and measurement errors) have been identified in the empirical literature which make firms' investment expenditure less sensitive to investment opportunities (see, Fazzari et al., 1988; Erickson and Whited, 2000). Thus, high sensitivity of investment to investment opportunity is regarded as a signal of high investment efficiency, i.e. higher explanatory power of investment opportunity in the investment equation suggests that investment is less affected by frictions and therefore more efficient (see, Chen et al., 2011).

Besides, in column (1), the full sample shows a significant negative response to the quadratic term of sales growth. This finding is consistent with our theoretical prediction of ambiguity aversion. The result suggests that the marginal response of investment to sales growth is decreasing. In other groups, we cannot find the positive coefficient of the quadratic term.

This table reports the estimates obtained with system GMM estimator. m3 tests do not indicate significant problems with model specification. The instrument sets are all the regressors lagged 3 times and longer for the first differenced equation and lagged twice for the level equation. We also present p values of Hansen/Sargan tests. However, Blundell et al. (2000) shows that when using system GMM on a large panel data, the Sargan test tends to over-reject the null hypothesis of instrument validity. Given the size of our panel, we therefore pay little attention to the J test.

Table 4.6: Investment, sales growth and cash flow

VARIABLES	(1) full sample	(2) private	(3) SOE	(4) foreign	(5) collective
Sales growth	0.551***	0.788***	0.472***	0.732***	0.618***
	(0.0828)	(0.0718)	(0.0726)	(0.105)	(0.123)
Sales growth squared	-0.0296	-0.465***	-0.388***	-0.697***	-0.397*
	(0.176)	(0.123)	(0.148)	(0.143)	(0.217)
$CF_{i,t}/K_{i,t-1}$	0.261***	0.122***	0.0604*	0.0915***	0.0503**
	(0.0101)	(0.0123)	(0.0311)	(0.0185)	(0.0250)
Observations	1,269,561	797,057	112,017	194,424	109,681
Number of id	398,686	262,950	34,175	51,505	34,977
m1	0	0	0	0	0
m3	0.377	0.863	0.882	0.323	0.647
Hansen test p-value	0	0	0.837	2.19e-06	0.344

Notes: This table reports the estimates obtained with system GMM estimator. $CF_{i,t}/K_{i,t-1}$ is cash flow rate over lagged capital, we use current cash flow divide lagged tangible assets. The instrument sets are all the regressors lagged 3 and 4 times for the first differenced equation and lagged twice for the level equation. Time dummies, industry dummies, time interacted with industry dummies are included. Figures in parentheses are asymptotically standard errors. m1 and m3 are p values of AR(1) and AR(3) tests.

Table 4.6 reports the results of the regression including cash flow (Equation 4.6). The instrument sets are all the regressors, namely sales growth, sales growth squared, and $CF_{i,t}/K_{i,t-1}$, lagged 3 and 4 times for the first differenced equation and lagged twice for the level equation. Time dummies, industry dummies, time interacted with industry dummies are included.

We find consistent results as in Table 4.5. The quadratic term of sales growth have significantly negative effect on investment when we split the full sample by different ownerships. We also find that private firms have the highest investment cash flow sensitivity, this is consistent with Guariglia et al. (2011).

4.7.2 Capital adjustment and uncertainty

We then estimate Equation (4.7). The results are reported in Table 4.7. Empirically the uncertainty is measured with a 3-year moving standard deviation of the unpredictable part of the cash flow of sales of goods and services. We follow the method suggested by Caglayan et al. (2012). We estimate an AR(1) model of the logarithm of sales augmented with time and industry-time specific dummies.

Table 4.7: Negative effect of uncertainty

	(1)	(2)	(3)	(4)	(5)
VARIABLES	full sample	private	SOE	foreign	collective
Sales growth	0.320***	0.227*	0.443***	0.470***	0.329
	(0.0952)	(0.133)	(0.107)	(0.154)	(0.201)
Sales growth squared	1.491***	1.238***	0.123	0.801**	0.217
	(0.287)	(0.343)	(0.153)	(0.325)	(0.307)
uncertainty	-0.0366	-0.0360	0.0310	0.00579	-0.0886
	(0.0315)	(0.0369)	(0.0574)	(0.0530)	(0.0872)
uncertainty*sales growth	-0.646***	-0.493***	-0.482***	-0.642***	-0.289
	(0.110)	(0.134)	(0.154)	(0.189)	(0.296)
$CF_{i,t}/K_{i,t-1}$	0.257***	0.305***	0.220***	0.174***	0.199***
	(0.0119)	(0.0154)	(0.0453)	(0.0190)	(0.0297)
Observations	597,792	358,791	52,061	117,055	47,067
Number of id	219,165	142,535	17,294	35,379	16,796
m1	0	0	0	0	0
m3	0.849	0.752	0.764	0.766	0.0959
Hansen test p-value	6.07e-10	0.000159	0.596	0.161	0.00511

Notes: This table reports the estimates obtained with system GMM estimator. The instrument sets are all the regressors lagged 3 times and longer for the first differenced equation and lagged twice for the level equation. Time dummies, industry dummies, time interacted with industry dummies are included. Figures in parentheses are asymptotically standard errors. m1 and m3 are p values of AR(1) and AR(3) tests.

In Table 4.7, the estimates are obtained with system GMM estimator. The instrument sets are all the regressors lagged 3 times and longer for the first differenced equation and lagged twice for the level equation. Time dummies, industry dummies, time interacted with industry dummies are included.

If we compare the results of Table 4.6 with Table 4.7, we find that the coefficients of the quadratic terms are no longer significantly negative. The significant positive coefficient can be found in column (1) (2) and (4).

The interaction term, $uncertainty * salesgrowth$ is to test how uncertainty affects investment-investment opportunity sensitivity. The coefficients are statistically and economically significant for the full sample, private firms, SOEs and foreign firms respectively. For example the coefficient of $uncertainty * salesgrowth$ in column (1) is -0.646 and the average uncertainty of the full sample is 0.3. Thus, on average, uncertainty can reduce the investment-investment opportunity sensitivity by 0.1938. The results shows that the concave relationship between investment and sales growth could be explained by uncertainty. The result is consistent with real option theory, that when uncertainty is high, firms will 'wait and see', and thus less sensitive to demand shocks or other signals (Dixit and Pindyck, 1994; Bloom et al., 2007; Bloom, 2009).

This result also suspects the monotonic relationship between financing constraints and investment-cash flow sensitivity. The investment-cash flow sensitivity may be also because of measurement errors or misspecifications of investment opportunity Erickson and Whited (2000); Cooper and Ejarque (2003). More specifically, we find that the coefficient of cash flow for private firms is the highest (0.305). If private firms are financially constrained but uncertainty is zero, the coefficients of quadratic terms should still be negative. This is because, according to financial constraint hypothesis, firms cannot invest as much as they want. Therefore when sales growth is high, constrained firms should be less sensitive to demand shocks. However, when we control uncertainty, we find the quadratic terms are significantly positive for private, foreign firms and SOEs. So, here we cannot find that the financial constraint is a big problem. Uncertainty seems more problematic. Although private firms still have the highest investment cash flow sensitivity, it is not convincing enough to prove the monotonic relationship between financing constraints and the sensitivity.

4.7.3 Investment cash flow sensitivity, uncertainty and ambiguity aversion

Table 4.8 reports the investment-cash flow sensitivity under the framework of ambiguity aversion, which is specified in Equation (4.8). We also use the interaction term (of uncertainty and cash flow) to study how uncertainty can affect investment cash flow sensitivities. In our theoretical model, we predict that when firms averse to uncertainty, they will use cash flow as an indicator to make investment decisions. Therefore, empirically we interact uncertainty with cash flow, we expect the coefficient of the interaction term to be positive.

Table 4.8: Investment-cash flow sensitivity and uncertainty

	(1)	(2)	(3)	(4)	(5)
VARIABLES	full sample	private	SOE	foreign	collective
Sales growth	0.302***	0.174	0.420***	0.450***	0.258
	(0.0944)	(0.131)	(0.105)	(0.149)	(0.203)
Sales growth squared	1.589***	1.442***	0.0964	0.855***	0.451
	(0.282)	(0.333)	(0.145)	(0.311)	(0.296)
uncertainty	-0.0941	-0.175**	0.0406	-0.0224	0.0514
	(0.0640)	(0.0783)	(0.0574)	(0.0847)	(0.103)
uncertainty*sales growth	-0.683***	-0.536***	-0.448***	-0.656***	-0.200
	(0.110)	(0.134)	(0.153)	(0.189)	(0.305)
$CF_{i,t}/K_{i,t-1}$	0.218***	0.200***	0.178***	0.168***	0.248***
	(0.0393)	(0.0517)	(0.0617)	(0.0429)	(0.0396)
uncertainty*$CF_{i,t}/K_{i,t-1}$	0.116	0.275**	0.167	0.0361	-0.206
	(0.117)	(0.139)	(0.222)	(0.141)	(0.166)
Observations	597,792	358,791	52,061	117,055	47,067
Number of id	219,165	142,535	17,294	35,379	16,796
m1	0	0	0	0	0
m3	0.840	0.784	0.767	0.751	0.0673
Hansen test p-value	3.91e-09	0.000727	0.184	0.188	0.0214

Notes: This table reports the estimates obtained with system GMM estimator. The instrument sets are all the regressors lagged 3 times and longer for the first differenced equation and lagged twice for the level equation. Time dummies, industry dummies, time interacted with industry dummies are included. Figures in parentheses are asymptotically standard errors. m1 and m3 are p values of AR(1) and AR(3) tests.

A very interesting result could be found from private firms (in column (2)). The coefficients of the uncertainty and cash flow interaction term ($uncertainty * CF_{i,t}/K_{i,t-1}$) is significantly positive. This suggest that high uncertainty will make private firms more sensitive to cash flow but less sensitive to investment opportunities. For example, in column (2), the coefficient of ($uncertainty*CF_{i,t}/K_{i,t-1}$) is -0.536. If uncertainty increases by 0.1, the investment sensitivity to sales growth will decrease by 0.0536.

The coefficient of $uncertainty * CF_{i,t}/K_{i,t-1}$ is also economically significant. When uncertainty is zero, the sensitivity of investment to cash flow is 0.2. If uncertainty increases by 0.1 then the investment-cash flow sensitivity will increase by 0.0275. This is again consistent with our key hypothesis, that uncertainty aversion will make non-constrained firms look constrained and show higher investment-cash flow sensitivities.

For SOEs and foreign firms, we find that uncertainty has no significant impact on investment cash flow sensitivity. The evidence, although not as strong as private firms, show that cash flow is still an important indicator for investment decisions when uncertainty is high and demand shocks are less important. So, here we use another channel of explaining investment cash flow sensitivities.

These findings also have some policy implications. When firm level uncertainty is high, firms will wait and see. Increasing investment opportunities may be less effective than increasing cash flow.

4.7.4 Robustness tests

We conduct a number of robustness tests. In Table 4.8 we use the interaction term (uncertainty*$CF_{i,t}/K_{i,t-1}$) to measure how uncertainty affects investment cash flow sensitivity, and we find that for private firms, high uncertainty will increase investment cash flow sensitivity. This finding is consistent with our ambiguity aversion hypothesis, that firms make investment decisions based more on cash flow but not investment opportunities when uncertainty is high.

To test if our finding is robust, we also use two dummy variables, namely $HIGHUNC_{i,t}$ and $LOWUNC_{i,t}$, to capture high and low uncertainty [7]. The results are reported in Table 4.9. The table reports system GMM estimators. The instrument sets are all the regressions lagged 3 times and longer for the first differenced equation and lagged

[7] $HIGHUNC_{i,t}$ equals to one if a firm's uncertainty is higher than the median value of each year. $LOWUNC_{i,t}$ equals to one if a firm's uncertainty is lower than the median value of each year.

twice for the level equation. We include time dummies, industry dummies and time interacted with industry dummies.

The results are consistent with what we find in Table 4.8. Column (1) reports the results estimated with full sample. We find that investment cash flow sensitivity will be high when uncertainty is high. This could also be found in private, SOEs and collective groups. A χ^2 test suggests that the difference between the cash flow coefficients of firms with different degrees of uncertainty is statistically significant at the 1% level with full sample. The two coefficients are also significantly different from each other at 5% level with the sample of private and collective firms.

The results show that high uncertainty can economically significantly affect investment cash flow sensitivity: the sensitivity of private firms is 0.338 for high uncertainty firm-years and 0.188 for low uncertainty firm-years; the sensitivity for high uncertainty firm-years of SOEs and collective firms are twice and three times larger than for low uncertainty firm-years respecitively.

The result is in line with our theoretical prediction that uncertainty is a link between investment and cash flow. Financing constraint problem is not the only explanation of investment cash flow sensitivity (FHP, 1988). In addition the findings support the argument that financing cash flow sensitivity is because of some misspecification of investment opportunities (Erickson and Whited, 2000; Cooper and Ejarque, 2003), uncertainty and confidence (how firm managers averse to uncertainty) are not observable from fundamentals.

Yet, this finding could be questionable. It would be very controversial if firms facing high uncertainty are also financially constrained. If so, it will be hard to argue that high investment cash flow sensitivity is caused by uncertainty. Here we control firm size, big and small, and split our sample. We define that a firm is big if its size is higher than median value of each year, and the others are small. Firm size is usually used to measure financial constraints.

The results are reported in Table 4.10. There is no evidence showing that small firms have higher investment-cash flow sensitivity than big firms. Actually, we find that in the groups of private and SOEs, big firms have higher sensitivity than small firms. So, this clarifies our doubt. We find that there is no monotonic relationship between investment cash flow sensitivity and financial constraints. As the result, our argument, that high uncertainty will make firm investment refer more to cash flow, is

Table 4.9: Robustness: investment-cash flow sensitivity under high and low uncertainty

VARIABLES	(1) full sample	(2) private	(3) SOEs	(4) foreign	(5) collective
Sales growth	0.247**	0.121	0.434***	0.519***	0.314
	(0.0975)	(0.136)	(0.105)	(0.151)	(0.196)
Sales growth squared	1.896***	1.692***	0.0423	0.817***	0.0368
	(0.279)	(0.343)	(0.144)	(0.312)	(0.298)
uncertainty	-0.115**	-0.137**	-0.00519	0.0430	-0.148
	(0.0450)	(0.0576)	(0.0569)	(0.0682)	(0.0990)
uncertainty*sales growth	-0.682***	-0.509***	-0.444***	-0.702***	-0.357
	(0.118)	(0.149)	(0.152)	(0.188)	(0.286)
$CF_{i,t}/K_{i,t-1}*HIGHUNC_{i,t}$	0.287***	0.338***	0.245***	0.149***	0.245***
	(0.0257)	(0.0303)	(0.0591)	(0.0346)	(0.0523)
$CF_{i,t}/K_{i,t-1}*LOWUNC_{i,t}$	0.178***	0.188***	0.122**	0.177***	0.0806***
	(0.0239)	(0.0390)	(0.0487)	(0.0244)	(0.0279)
H_0: coefficients of $CF_{i,t}/K_{i,t-1}*HIGHUNC_{i,t}$ equals to coefficients of $CF_{i,t}/K_{i,t-1}*LOWUNC_{i,t}$ (p-value)	0.00130***	0.0185**	0.1601	0.5735	0.0190**
Observations	588,076	352,929	50,724	115,559	46,312
Number of id	215,845	140,242	16,931	35,021	16,550
m1	0	0	0	0	
m3	0.892	0.774	0.165	0.153	0.0584
Hansen test p-value	1.06e-08	0.00340	0.476	0.138	0.00118

Notes: This table reports the estimates obtained with system GMM estimator. Time dummies, industry dummies, and time interacted with industry dummies are included. The instrument sets are all the regressors lagged 3 times and longer for the first differenced equation and lagged twice for the level equation. Figures in parentheses are asymptotically standard errors. m1 and m3 are p values of AR(1) and AR(3) tests. $HIGHUNC_{i,t}$ and $LOWUNC_{i,t}$ are dummy variables of high and low uncertainty.

robust. This pattern could be most obviously found in private firms.

Table 4.10: Robustness: investment-cash flow sensitivity and uncertainty big and small

VARIABLES	private	private	SOEs	SOEs	Foreign	Foreign	collective	collective
	Big	Small	Big	Small	Big	Small	Big	Small
Sales growth	0.634***	0.631***	0.549***	0.244**	0.503***	0.173	0.540***	-0.112
	(0.106)	(0.124)	(0.113)	(0.111)	(0.113)	(0.179)	(0.176)	(0.192)
Sales growth squared	0.608***	-0.0714	0.0130	-0.0554	0.288	-0.114	0.102	0.0484
	(0.230)	(0.216)	(0.140)	(0.0957)	(0.236)	(0.207)	(0.197)	(0.198)
uncertainty	0.0247	-0.0173	0.0423	-0.0149	0.0463	0.0157	0.129	-0.204***
	(0.0326)	(0.0326)	(0.0653)	(0.0588)	(0.0493)	(0.0612)	(0.0888)	(0.0755)
uncertainty*sales growth	-0.687***	-0.358***	-0.608***	-0.207	-0.630***	0.0219	-0.451*	0.236
	(0.115)	(0.137)	(0.181)	(0.126)	(0.139)	(0.213)	(0.261)	(0.219)
$CF_{i,t}/K_{i,t-1}$	0.188***	0.0798***	0.170***	0.157***	0.111***	0.0135	0.141***	0.151***
	(0.0263)	(0.0225)	(0.0359)	(0.0344)	(0.0200)	(0.0308)	(0.0266)	(0.0320)
Observations	170,904	180,291	31,347	20,156	81,502	33,161	21,813	24,562
Number of id	67,301	88,380	9,807	8,196	24,970	13,874	7,568	10,844
m1	0	0	0	0	0	0	0	0
m3	0.124	0.332	0.294	0.209	0.772	0.500	0.324	0.660
Hansen test p-value	0.0210	0.699	0.612	0.389	6.13e-05	0.0748	0.410	0.0302

Notes: This table reports the estimation results using a system GMM estimator. Time dummies, industry dummies and time interacted with industry dummies are included. Instruments are all lagged 3 times or more; Figures in parentheses are asymptotically standard errors. J is a test of over-identifying restrictions. $m1$ and $m3$ are test of 1st and 3rd serial correlations in the first-differenced residuals.

4.8 Conclusion

Investment cash flow sensitivity has been discussed for decades and proposed as a useful indicator of financial constraints since FHP (1988). Yet, some empirical data makes us question this argument. We find that for most firms in China, cash flow is far larger than investment, so it is inappropriate to claim that investment cash flow sensitivity is monotonically related to financial constraints. So, we are trying to re-interpret investment cash flow sensitivity based on the framework of uncertainty and ambiguity aversion.

We apply the dynamic structure model with uncertainty and ambiguity aversion suggested by Bloom et al. (2007), and Ilut and Schneider (2012). We find that under uncertainty and ambiguity aversion, firm investment shows a decreasing marginal response to demand shocks and firms will consider more about cash flow. In line with our theoretical framework, we build our empirical specification based on q model. We use the data set of Chinese firms and there are some very interesting findings. First, there is a decreasing marginal response to demand shocks, and this is consistent with our theory. Second, we find no significant evidence indicating that private firms in China are financially constrained from aggregate level. Third, we find that private firms in China show higher investment cash flow sensitivity when uncertainty is high. This is consistent with our ambiguity aversion assumption.

Our results suggest a new channel of explaining investment cash flow sensitivity: firms which show high investment cash flow sensitivity may not be because of financial constraints, but ambiguity aversion.

There is one policy implication of this chapter. When uncertainty is high, firms care more about cash flow than investment opportunities. Therefore, if policymakers aim to increase fixed capital investment, implementing monetary policies, such as quantitative easing, could be more helpful than stimulating fundamentals.

Appendix

4.A Variable construction

Tangible fixed assets: total fixed assets minus intangible assets

Real sales: total sales of goods and render of services deflated by provincial price index

sales growth: difference between logarithm of current real sales and logarithm of lagged real sales

Cash flow: net cash flow plus depreciation

Fixed investment: difference between the book value of tangible fixed assets

Uncertainty:the uncertainty is measured with a 3-year moving standard deviation of the unpredictable part of the cash flow of sales of goods and services.

Deflators: taken from the China Statistical Yearbook (various issues), which are published by the National Bureau of Sta- tistics of China. The provincial capital goods deflator was used to deflate the capital stock, and the provincial producer price indices (PPI) for manufactured goods to deflate other variables.

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Chapter 5

Firm Cash Holdings, Uncertainty and Confidence Shocks

5.1 Introduction

When firms try to maximise their values, their managers need to think over problems such as 'financial constraint and uncertainty'. These problems require firms to adjust their behaviour and use different strategies to minimise negative impacts. Fazzari et al. (1987) use investment-cash flow sensitivity to show that financially constrained firms will rely more on cash flow to make investment decisions. In addition firms may adjust their behaviour with uncertainty. Dixit and Pindyck (1994) suggest that firms will 'wait and see' when uncertainty is high.

Despite the adjustment of investment decisions, firms will also adjust their liquidity demand. There are a number of studies on why firms hold cash.

In these studies, the 'trade off' theory (Opler et al., 1999) and 'precautionary saving' are two mostly accepted explanations. The 'trade off' theory suggests that firms will save money because of transaction costs. More specifically, a shortage of cash will increase the marginal cost of external finance. 'Precautionary saving' suggest that firms hold cash as a buffer to hedge adverse shocks, although holding cash is costly since interest is low and also taxed (Nikolov and Whited, 2014). There are also many other explanations of savings policy. Agency problem suggests that managers and shareholders have different interests. Managers have an incentive to hold cash rather than distribute (Jensen, 1986). Some evidence could be found with empirical studies. For example, (Opler et al., 1999) show that firms have a target savings level, and cash accumulation is not significantly correlated with investment. Dittmar and Mahrt-Smith (2007) find that the value of cash will be lower if the agency problem is greater. Tsoukalas et al. (2016) suggest that firms save cash because of high fixed costs, which could generate an inaction zone.

From these papers, there are two papers which study precautionary savings from the perspective of cash flow sensitivity of cash. Almeida et al. (2004) find that the cash flow sensitivity of cash is positive. In addition, it is an indicator to identify financial constraints. The reason is because constrained firms will save cash out of income to finance investment in future. Riddick and Whited (2009) suggest that savings has a negative relationship with cash flow. They study savings policy based on 'trade-off' theory and 'precautionary saving'. They build a dynamic model and simulated data with policy function. The results are also plausible: firm save when investment opportunities are bad, and use cash when investment opportunities are good. In this way, firms can maximise their values and profits.

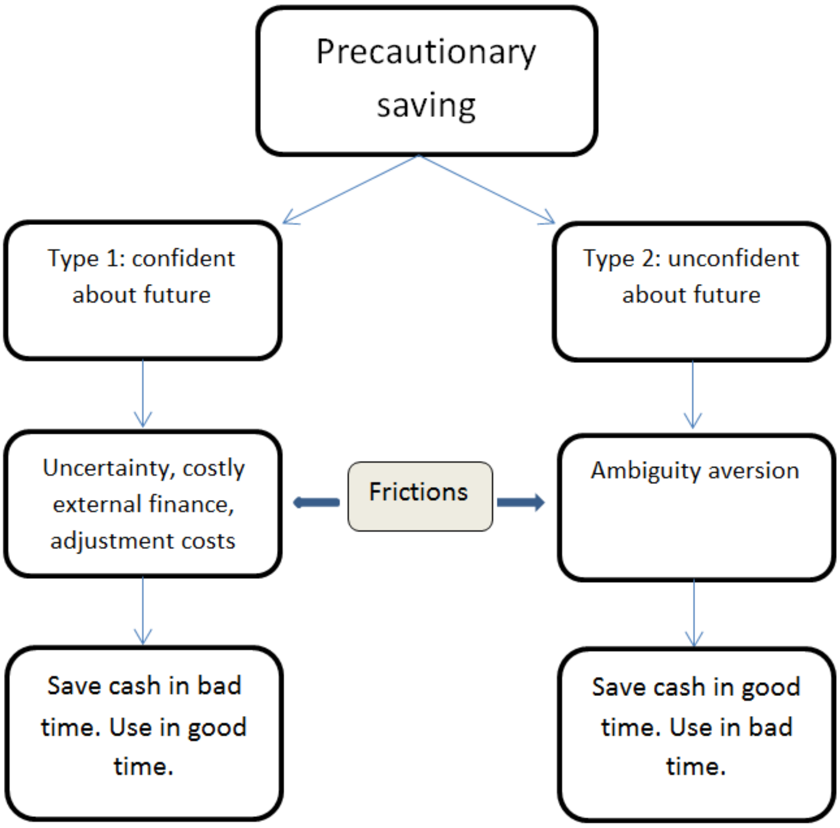
Since both papers agree that firms save for precautionary reasons, why do they have conflicting results? One contribution of this chapter is to answer this question. We want to take a deeper look at the relationship between savings and uncertainty.

Almeida et al. (2004) only take financing constraints into consideration, but when we use dynamic structure model as Riddick and Whited (2009), we can never get the result to be consistent with Almeida et al. (2004) by maximising firm value. In Riddick and Whited (2009), they assume that firms have a homogeneous attitude towards uncertainty. In other words, firms are neutral to uncertainty and there is no confidence shock. 'Uncertainty' generates positive and negative shocks, but firms respond to the shocks rationally by adjusting fixed capital and liquidity level. Finally the only goal is to maximise firm value. Ilut and Schneider (2014) argue that people are averse to ambiguity. When people lose their $confidence$, they will behave as if they are going to face the 'worst case' in future. 'Ambiguity aversion' is often used to show that agents have pessimistic beliefs. We can apply this idea to the context of our study: firms will act as if they are going to face the 'worst outcomes' when they are uncertain about the future. We call the loss of confidence as a 'negative confidence shock'. Thus, if we take confidence shocks in to consideration, we can get different results from previous studies.

We suggest that uncertainty can affect savings policy through two channels: idiosyncratic shock of productivity (or demand) and confidence shock. The idiosyncratic shock is most common, which suggests that firms' productivity will be affected by a random factor. In this chapter the idiosyncratic shock is the only source of 'uncertainty'. The level of uncertainty (high or low) is determined by the volatility of the idiosyncratic shock. The confidence shock suggests that firms have different attitudes toward the random factor. As such, the purpose of 'precautionary savings' can be split in to two: liquidity demand in good times and bad times. During good times, firms have good investment projects, and income is not sufficient. Thus, managers will use 'precautionary savings' to finance the project. We call this as *type* 1 precautionary savings. During the bad times, 'precautionary saving' is used to hedge adverse shocks in order to keep firms safe. We call the savings for hedging purpose as *type* 2 precautionary savings. This is also a contribution of our research. Previous studies usually discuss precautionary reason as a whole. In this chapter, we split it into two components. We illustrate the intuitive idea of two types of 'precautionary savings' in Figure

5.1

Figure 5.1: Two types of precautionary savings



We build a dynamic model with financing and investment based on 'trade-off' theory and precautionary saving hypothesis. Our research is closely related to Riddick and Whited (2009) and Tsoukalas et al. (2016).

Our improvement is that we take confidence shock into consideration. In short, managers have different goals. Maximising shareholders' benefit is important, but managers also need to consider the safety of their company. So, a manager needs to balance profitability and stability. If managers have two goals, there will be two types of precautionary saving: savings used to invest, and savings used to hedge bad shocks.

Besides, we will also do many experiments by changing some parameters, such as external financing costs, adjustment costs. We solve the theoretical model numerically and simulate firm-level panel data. We find that with strong confidence, firms' savings policy is identical with Riddick and Whited (2009), but with weak confidence, the nature of savings policy is more close to Almeida et al. (2004). We also empirically test cash-cash flow sensitivity with simulated data. We find that if firms are not averse to uncertainty, the cash-cash flow sensitivity is negative, but if they lose confidence and are averse to uncertainty, it is positive.

We then use the real company data for empirical study. The data set is a panel of listed companies over the period 1998-2010 and 15,516 observations. We find some very interesting features of Chinese listed firms. The firms are very large and listed, in other words, they have more formal channels to get external finance than unlisted and small firms (Allen et al., 2005). However, although the firms are listed and large, they hold high cash reserves. Interestingly, firms with higher Tobin's q and sales growth hold more cash. This is also consistent with the survey of Lins et al. (2010). They find that non-operational savings is mainly used to guard against unexpected income shocks in bad times, but not to invest. According to Allen et al. (2005), in China neither legal nor financial systems are not well developed. Therefore, negative shocks are more likely to cause a significant loss. Another motivation of this chapter is to find how ambiguity aversion affect cash holdings in China.

We then test the same regression on real data to test cash-cash flow sensitivity first. We find a positive sensitivity of cash to cash flow. This is consistent with Almeida et al. (2004). Since it is hard to measure firm specific confidence with real data, we could test how firms make savings policy with different level of uncertainty. Based on the specification of Almeida et al. (2004), we add two control variables to the model, uncertainty and an interaction term of cash flow and uncertainty. Our finding is that firms with high uncertainty will hold more cash, and uncertainty can increase cash-cash flow sensitivity. We then estimate the value of cash holdings according to Faulkender and Wang (2006) and Dittmar and Mahrt-Smith (2007). We find that uncertainty can decrease the marginal value of cash holdings. Holding uncertainty constant, the marginal value of cash holdings decreases more because of uncertainty after the financial crisis. Firms hold more excess cash because they are more averse to uncertainty.

Section 2 will theoretically introduce savings policy uncertainty and confidence shocks. Section 3 will briefly introduce savings policy in China. Section 4 will present the nature of savings policy with simulated data. We will show how savings respond to productivity shocks when we change the values of different parameters. In section 5, we will introduce the empirical data and savings policy of Chinese firms. Section 6, presents our regressions and discuss empirical results, and section 7 is conclusion.

5.2 The model

We study investment and savings policy with a discrete-time, infinite-horizon, partial-equilibrium dynamic model. We will firstly introduce production technology or demand factor with a Cobb-Douglas revenue function. Second, we will introduce financing policy. We suggest that external finance is costly. Then we will discuss how confidence shock and uncertainty affect managers' utility. Finally, we solve the optimal financing policy.

5.2.1 Production function and investment

The Cobb-Douglas revenue function could be written as:

$$\pi = Zk^{\gamma} \tag{5.1}$$

Where π_t is production revenue. Z_t is a productivity or demand factor, and it is the only source of uncertainty. γ is the share of capital in revenue function. In addition, γ is greater than 0 but smaller than 1, which suggests that a firms' marginal capital production is decreasing. Define $z_t = \ln(Z_t)$, the productivity follows an AR(1) process:

$$z' = \rho z + \varepsilon' \tag{5.2}$$

where, with a prime means in a variable in the next period and no prime means in current period. The ρ is a serial correlation of productivity, and ε_t is normally distributed with 0 mean and σ standard deviation:

$$\varepsilon_t \overset{i.i.d}{\sim} N(0, \sigma_{\varepsilon}^2)$$

Investment is I, and the transition of capital is:

$$k' = I + (1 - \delta)k \tag{5.3}$$

δ is the capital depreciation rate. We also include capital adjustment cost, which could be denoted as

$$G(I, k) = \frac{g}{2}\left(\frac{I}{k}\right)^2 k \tag{5.4}$$

In this chapter, we only take quadratic adjustment costs into consideration, g is the parameter of quadratic adjustment costs. Fixed adjustment costs are not included because we find fixed costs have limited affect on saving policy but will make the computation much more complicated. This is also stated in Nikolov and Whited (2014).

5.2.2 Costly external finance

The external financing cost is one key reason that firms save money. If the borrowing cost is low and accessible, firms have no incentive to save. One reason that firms accumulate cash is because they need money but the cost is too high. As the result they will use the money they reserve. Assume that c is the current cash holding, and c' denotes cash holding in next period. The dividend payment is

$$d(k, k', c, c', z) = Zk^{\gamma} - k' + (1-\delta)k - \frac{g}{2}\left(\frac{I}{k}\right)^2 k + (1+r)c - c' \tag{5.5}$$

r is the interest rate of savings. If $d(k, k', c, c', z)$ is positive, firms will pay dividends, but if $d(k, k', c, c', z)$ is negative, firms need to borrow money. In line with Nikolov and Whited (2014), the external financing cost is linearly related to money borrowed.

$$\phi(d) = \lambda d(k, k', c, c', z) 1_{[d(k,k',c,c',z)<0]} \tag{5.6}$$

λ is a borrowing cost, which is larger than the risk free rate r. When $d(.) < 0$, firms need pay for external finance. In this case, firms will not choose to accumulate cash and save money at the same time. In other words, before firms need external finance, they will firstly exhaust their savings.

5.2.3 Negative confidence shock and precautionary savings

As we introduced above, there are some puzzles in cash holdings behaviour. The first is that with the dynamic model we introduced above, savings is negatively related to cash flow. However, Almeida et al. (2004) find it is positive. In addition, Opler et al. (1999) find that firms with strong growth opportunities hold more cash. Why do theories under similar assumptions have contrary results?

Secondly, the dynamic model above suggest that firms can adjust their savings flexibly according to productivity shocks. Which means, when investment opportunity is high, firms will spend cash to buy fixed capital in order to maximise profit. There is no target savings level at all, but there are many empirical studies which show that firms have a target savings level.

Thirdly, the model above suggests that firms will not save and borrow money simultaneously. However, in the real life, this is not true. Most firms will borrow and save at same time. As Lins et al. (2010) find, firms use credit lines to fund business opportunities, while using savings to hedge bad income shocks. That is one reason why the theory mismatches the reality.

So, we are going to find a theoretical explanation to solve these puzzles. We introduce the confidence shocks into the dynamic structural model. According to agency conflicts, we know that managers have different goals. For a manager, maximising shareholders' benefit is important but they also need to think about firms' long run survival. Then, we need to know how much firms will save. Or, what is the target saving level. According to Ilut and Schneider (2014) when firms are uncertain about the future, firms will behave as if they are going to face the worst outcome. Here, in terms of savings policies, we suggest that firms will use savings to hedge the worst income shock.

$$\ln(\pi^{\prime,worst}) = (\rho z - b\sigma) + \gamma \ln(k) \tag{5.7}$$

Where b is a parameter, which is used to measure expected worst income shocks. We also assume that income shock is also related to uncertainty, σ. It is easy to interpret this because firms with high uncertainty are more likely to face large income shocks. According to 'precautionary saving' theory, firms will need to use savings to hedge the income shortfall. We could write the process as:

$$s = c - (E(\pi') - \pi'^{worst}) \tag{5.8}$$

s is a measurement of the deferential between cash holdings and worst income shock. If s is smaller than zero, it means saving cannot cover income shock. According to our hypothesis, when firms are averse to uncertainty, managers have the preference to hold cash to hedge bad shocks. If the risk cannot be covered with liquid assets, that may affect managers' utility. $E(\pi') - \pi'^{worst}$ is like a target of cash holdings. However, managers may have many goals and there may be many targets. Since in this chapter, we assume that income shock is the only source of uncertainty, for simplicity, we only use 'income shock' as target. So, the manager's utility function could be written as,

$$u(k, k', c, c', z) = d(k, k'c, c', z) - \phi(d) + as1_{[s<0]} \tag{5.9}$$

in which a is a parameter of confidence shock. $s1_{[s<0]}$ suggest that s will have negative impact on a manager's utility. Moreover, a is not a fixed number. Different managers have different preference towards uncertainty. Low a suggest that managers care more about $d(k, k'c, c', z)$, or firms value. High a suggest that they put firms' safety to priority. a could also adjust from time to time. High uncertainty may make firms more precautionary and more averse to uncertainty. Given the discount rate β, the Bellman equation of this problem is,

$$U(k,c,z) = \max\left\{u(k,k',c,c',z) + \beta E_{z'|z} U(k',c',z')\right\} \tag{5.10}$$

As the result, our model suggest that uncertainty can affect savings policies through two channels, idiosyncratic shocks and costly external finance, and confidence shocks.

5.3 Model simulation

5.3.1 Calibration

In line with Riddick and Whited (2009), $\pi = Zk^{\gamma}$. We set γ, capital elasticity, equal to 0.75. The serial correlation of productivity shock (ρ) is 0.66. As we assume, $\varepsilon_t \overset{i.i.d}{\sim} N(0, \sigma_{\varepsilon}^2)$. The standard deviation, σ_{ε}, is 0.125, which is close to the value used in Riddick and Whited (2009).[1] Linear external financing cost λ is 0.08[2]. We set the discount rate to be 0.96, which is between the value in Hennessy and Whited (2007) and Gomes (2001). Interest rate for savings r is 0.032[3], and it is important to make sure the value $\beta(1+r) < 1$. a represents the level of confidence. Low a represents firms which are confident and high a means firms are not confident or averse to uncertainty. We assume that a lies between a support [0, 0.5]. Also b is unknown but we assume that b lies on [0, 4]. The parameter of quadratic adjustment cost (g) are set to different values. According to Riddick and Whited (2009) they use a low adjustment cost,

[1] A negative standard deviation shock of productivity will decrease revenue by $(1-e^{-0.125})\pi$. Bloom et al. (2007) use a different production function, but we calculate a negative standard deviation shock of demand, which decreases decrease revenue from 0.026π to 0.16π. Bloom et al. (2007) assume that in a demand condition, the only source of uncertainty, follows a geometric Brownian random walk. Their assumption is different from ours. Comparing with Bloom et al, (2009), σ equal to 0.125 can generate a relatively large revenue shock. However, Nikolov and Whited (2014) estimate the σ form 0.262 to 0.311. As the result, we choose a middle value, 0.125.

[2] Since financial market in China is less developed, we assume that external financing cost is higher. According to the costly external finance assumption, external financing cost should be higher than risk free rate. I choose 0.08. However, Chinese financial system maybe different from US market. As such, we will do more experiments in the following sections. We allow external financing cost to be any number of the 20 equally discretized grid points in the support [0, 0.16]

[3] Interest rate for savings is the risk free rate. China 10-year government bond yield is around 4 percent. The income tax in China is 20%. So risk free rate r is 0.032.

0.049. However, Cooper and Haltiwanger (2006) suggests that g is 0.455 if we only take quadratic adjustment cost into consideration. Bloom (2009) use 0.5. So we choose 0.1, and we will do more experiment on adjustment costs with g, which lies on the support [0, 1][4].

We discretize the state variable capital, k into 25 grid points and c into 15 grid points. Marginal capital productivity equal (1-$\beta + r$). The productivity shock has 25 points support, [-6.5σ,6.5σ].[5] The productivity shock transforming in to a Markov process, with a transition matrix in Tauchen (1986).

5.3.2 Iteration

The maximization problem is solved with value function iteration with the process suggested by Adda and Cooper (2003) [6]. The results are two policy functions, $k' = p_k(k, c, z)$ and $c' = p_c(k, c, z)$. Given the values of this period, the firms could find the optimal investment and savings policies in next period.

5.3.3 Experiments and theoretical implications

We solve the model via value function iteration on Bellman equation. We could find the optimal k' and c' via policy function and interpolation. We simulate data base on a random draw of z. Finally, we simulate a sample of 10,000 firms and over 200 years, and we only keep the last 20 years. We plot our simulated data with Lowess smoothing. Investment is $(k' - (1 - \delta)k)/(k + c)$ and Savings is $c/(k + c)$.

Savings and adjustment costs

We firstly plot the investment and savings policy with low adjustment costs and no confidence [7] (Figure 5.2). Horizontal axis is 'lz' which represents productivity shocks $\ln(Z)$; vertical axis is the percentage change of investment and savings. The panel is

[4] Chinese firms may have different capital adjustment costs with US firms due to various reasons, for example different capital structure, industries etc. When g is 0, it means that there is no adjustment cost and when g is 1, it means that Chinese firms need to pay more than twice as much as the US firms to adjust capital stock.

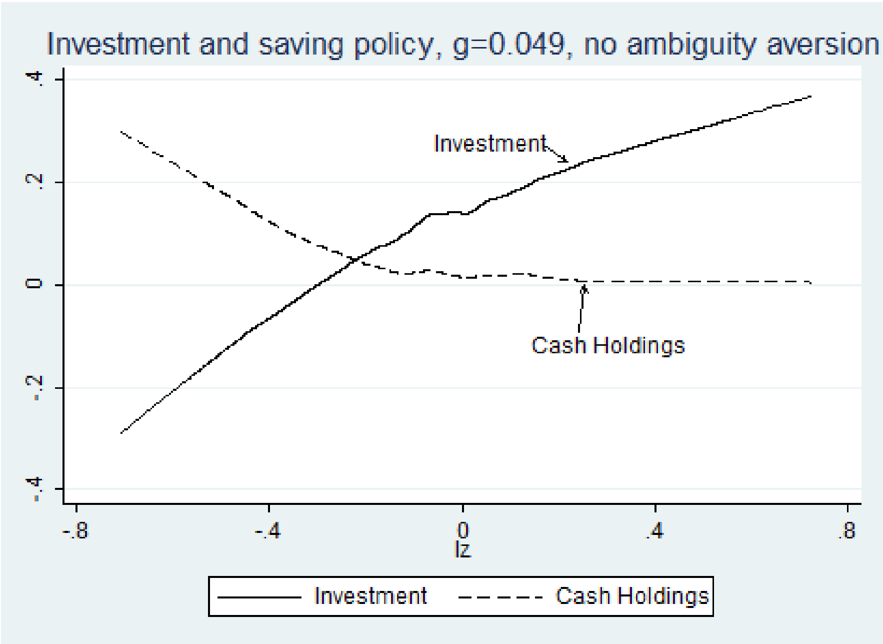
[5] We calculate the support depends on ρ and number of grid points.

[6] Detailed process could be found in the appendix.

[7] $a = 0$ and $g = 0.049$.

simulated with low adjustment costs and no ambiguity aversion[8]. We find that firms will save cash when productivity is low, and cash holding is almost zero when investment opportunities are high. This result is very close to Riddick and Whited (2009). The figure also shows that firms will divest (negatively invest) when productivity is low. It is not hard to understand this behaviour. When productivity is low, firms will divest to increase marginal capital productivity.

Figure 5.2: Investment and savings policy with low adjustment costs and no ambiguity aversion



Hite et al. (1987) argue that managers only keep profitable assets and sell assets if other firms have a comparative advantage. They investigate cases in the US, and they find that asset sales usually accompany resource reallocation. The assets move to higher valued uses.

Maksimovic and Phillips (2001) analyze how firm organization and characteristics affect asset sales with US manufacturing firms. They find that firms tends to sell assets when they are less productive than industry benchmark levels, when the selling division is less productive, when the firms have more productive assets in other industries, and when demand shocks are positive.

Warusawitharana (2008) also suggests that firms sell assets for efficiency reasons. When productivity is high, firms can invest to earn more revenue. In addition, they

[8]Here, in this chapter, ambiguity aversion means that firms or managers suffer from negative confidence shocks.

could save the liquidated fixed capital–cash. As the result, the savings policy could be interpreted as a transformation between fixed assets and liquid assets. The key is productivity. Also, if adjustment costs are low, firms can easily adjust fixed assets to liquid assets.

Another reason that firms liquidate fixed capital is because of costly external finance and financing constraints. Managers can then liquidate less profitable assets to obtain funds (Lang et al., 1995) and invest more profitable projects (Hovakimian and Titman, 2006).

We then raise the value of adjustment costs to 0.1 and 0.2 (Figure 5.3 and Figure 5.4). The results show that as we increase adjustment costs firms will decrease savings dramatically. Especially when we increase adjustment costs to 0.2, cash holdings decrease to almost 0. Meanwhile, firms are less likely to divest When adjustment costs are low (g = 0.049), and $\ln(Z)$ is around -0.7, firms will divest about 30% of total assets, but when adjustment costs are high ($g = 0.455$), at the same productivity level firms will divest only about 5%. We find that transforming between fixed assets to liquid assets is costly. Therefore, firms choose not to hold cash because liquidation is more costly than external finance. In the trade-off theory, we understand that holding cash is costly because risk free return is very low. From our model we suggest that holding cash is also costly because of adjustment costs.

Figure 5.3: Investment and savings policies with Medium adjustment costs and no ambiguity aversion

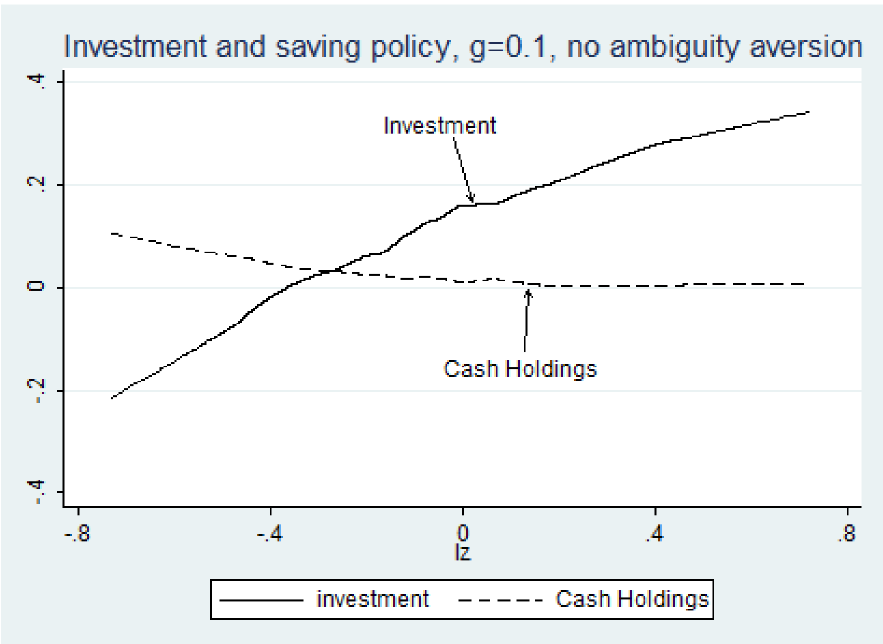
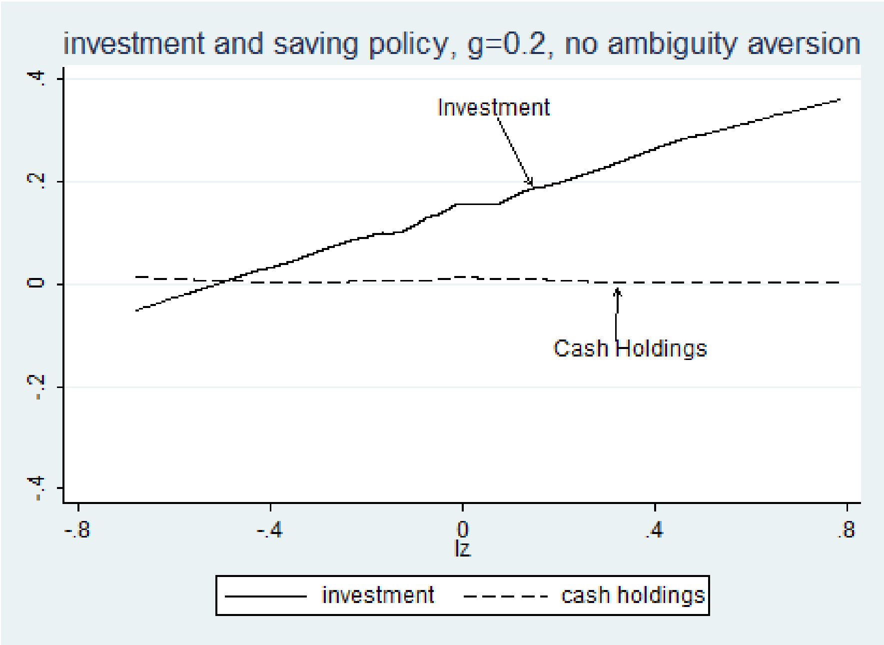
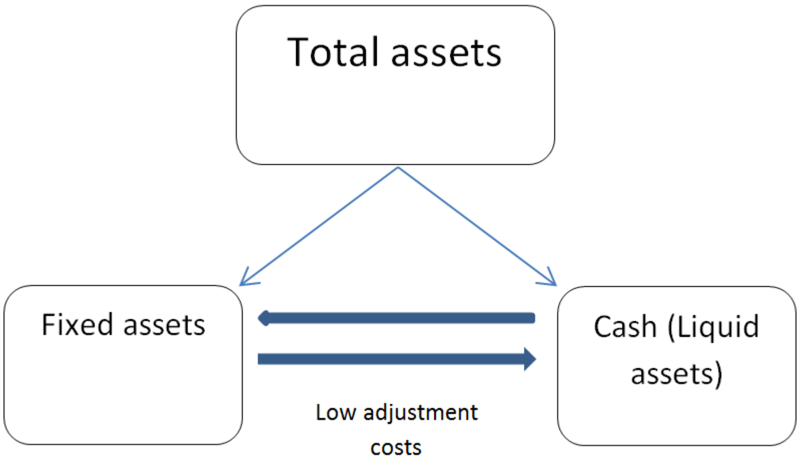


Figure 5.4: Investment and savings policies with high adjustment costs and no ambiguity aversion



We could illustrate the transforming mechanism in Figure 5.5. Cash could transform to fixed assets easily, but when adjustment costs are high, fixed cost cannot easily transform to cash.

Figure 5.5: Transforming between fixed assets and liquid assets

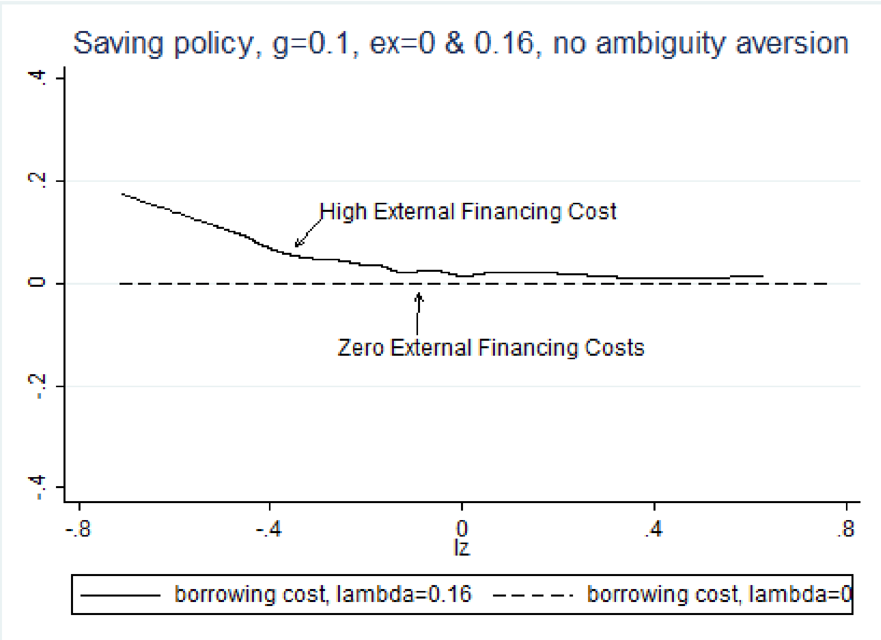


Cash, external financing costs, and uncertainty

According to the 'trade-off theory' and Gilchrist et al. (2014), firms are affected by financing constraints and uncertainty together. A single effect will not change firm decision significantly. We also test how cash holdings respond to financing constraints and uncertainty.

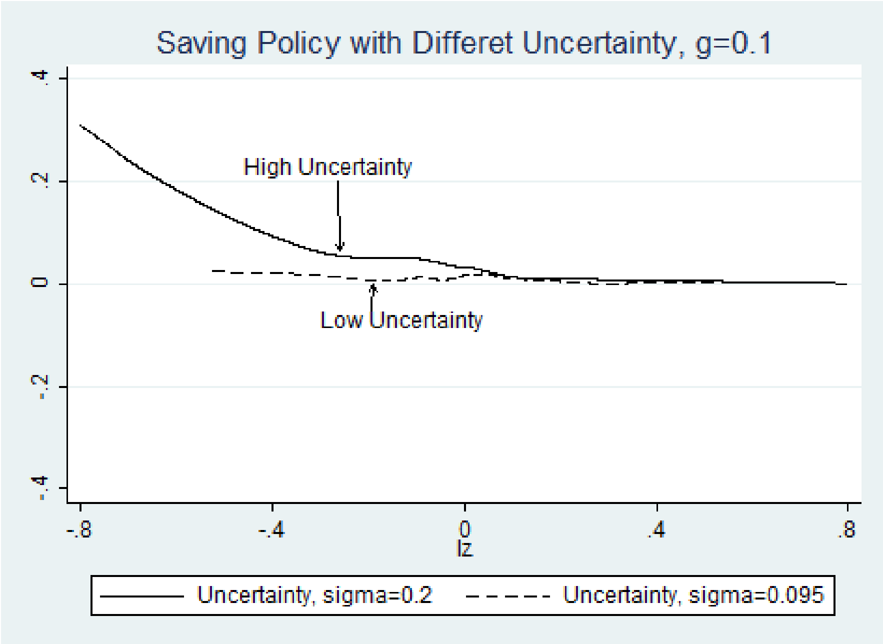
In Figure 5.6 we choose a Medium adjustment cost, 0.1, we find that firms with zero external financing costs will not save, but with high costs they will save more. In Figure 5.7 we report two savings policies with different uncertainty. We set the σ equal to 0.095 and 0.2 [9]. As the result, we find that uncertainty is necessary. Firms with low uncertainty almost do not save. These two graphs tell us that if uncertainty is the only friction, firms could borrow as much as they want when they need liquidity; if there is no uncertainty, firms could predict future precisely so they do not need to be 'precautionary'.

Figure 5.6: Saving policy with high and zero external financing costs



[9]The distribution of productivity (lz) is largely based on σ. Too small or too large σ will make the plots too short or too long.

Figure 5.7: Savings policy with high and low uncertainty



The evidence above suggests that 'low adjustment costs', 'uncertainty' and 'costly external finance' are three necessary factors for the first type of precautionary savings: savings during bad times and using in good times.

Savings policy and ambiguity aversion

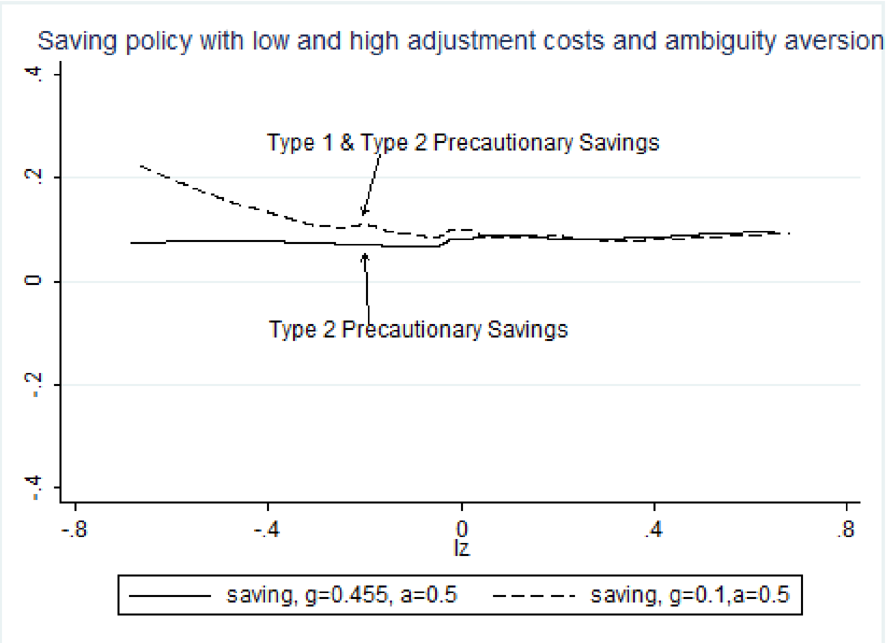
If a company is confident with its future, it will exhaust its cash holdings during good time. However, what will firms do when they are not confident? If the adverse shocks could threaten their survival, will they still hold no cash?

After we take negative confidence shocks into consideration, savings policy is dramatically changed. We plot the simulated data in Figure 5.8. We initially set $b = 2$ and $a = 0.5$ (the parameters in equation 5.7 and 5.9). The dash line shows a combination of two types of 'precautionary' savings. We find that with confidence shocks, firms will not use all of their cash holdings in good time, but they still save a lot in bad times.

When we increase adjustment costs g to 0.455, as estimated by Cooper and Haltiwanger (2006), we find that they first type of 'precautionary saving' is diminished. Because of ambiguity aversion, the second type of 'precautionary saving' remains (the solid line). We find a positive relationship between savings and productivity.

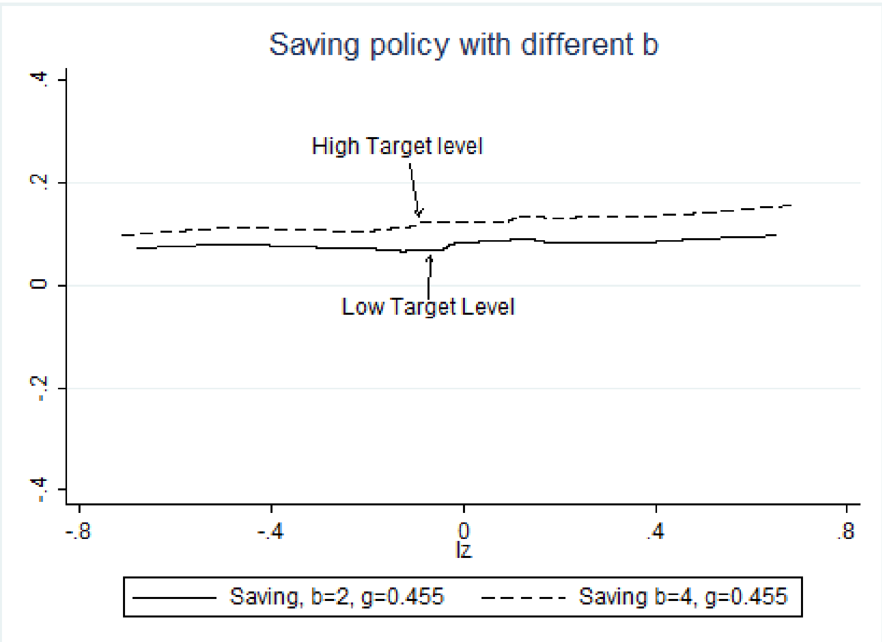
Another very important finding is that precautionary savings, because of ambiguity aversion, are not sensitive to adjustment costs. Firms still save when adjustment costs are high.

Figure 5.8: Savings policy with adjustment costs and ambiguity aversion



Of course, savings policy will also change because of different targets. In our model, savings are target on the differential between expected income and 'worst income'. This is determined by b. When we increase the value of b, we expect the differential will also increase. Figure 5.9 shows the savings policy with a different target. Here, we remove first type 'precautionary savings' with high adjustment costs. We find that firms will increase savings if we increase the target.

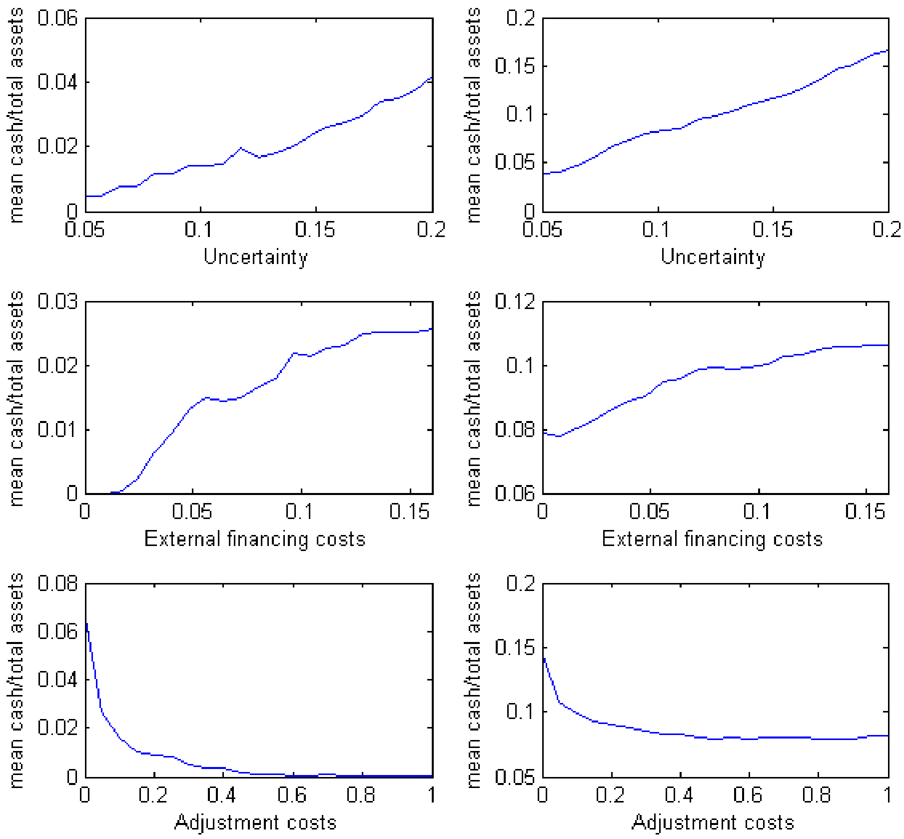
Figure 5.9: Savings policy with high and low targets



Finally we report the average savings by splitting the support of uncertainty, external financing cost,adjustment costs, a, and b with 21 points [10]. The results are reported in Figure 5.10 and 5.11. The three figures on the left are mean cash holding without ambiguity aversion. In other words, they are only type 1 cash holdings. The uncertainty (σ) could make firms save more. We increase σ from 0.05 to 0.2, and average savings rise from 0.5% to 4%. When we increase external financing costs, average savings will increase from 0 to 2.5%. However, adjustment costs can decrease cash holdings. We find that cash holdings drop dramatically if we increase adjustment costs (g) from 0 to 0.2. When g is higher than 0.4, firms will almost save nothing. The three figures on the right are mean cash with ambiguity aversion. The results are a combination of type 1 and type 2 savings. Still we find that uncertainty and financing costs will increase savings, and adjustment costs decrease cash holdings. However, if we remove the effect of type 1 savings effect, we find that type 2 cash holding is not sensitive to the change of external financing costs and adjustment costs. That is to say, type 2 cash holdings are only determined by uncertainty. The results are consistent with our model.

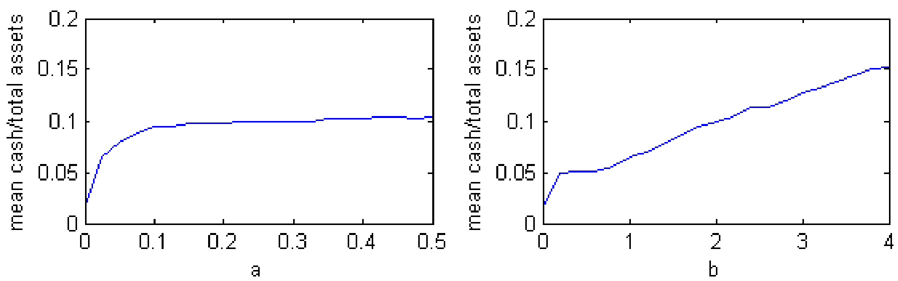
[10] We simulated totally 126 samples. Each sample contains 200,000 firm-years.

Figure 5.10: Average cash holdings without and with ambiguity aversion



Then we plotted the average cash holdings regarding different a and b. Increasing a from 0 to 0.5, we find that firms will hold more cash, because firms are more averse to uncertainty. We also find that increasing a from 0.1 to 0.5, savings only increase slowly. b is the target savings level. Changing the target will also change average savings.

Figure 5.11: Average cash holdings with different level of ambiguity aversion and targets



5.3.4 Empirical estimation on simulated data

Since savings depend on the attitude of uncertainty. If a firm wants to save cash and invest good projects (the first type precautionary savings), according to our theoretical prediction, the cash-cash flow sensitivity should be negative and if managers want to use cash to hedge cash flow shortfalls (the second type precautionary savings), we expected to observe positive cash-cash flow sensitivity.

To link the predictions with empirical tests, the regression could be written as:

$$\frac{\Delta c_{i,t}}{c_{i,t}+k_{i,t}} = \beta_0 + \beta_1 q_{i,t} + \beta_2 \frac{Cashflow_{i,t}}{c_{i,t}+k_{i,t}} + \beta_3 size_{i,t} + \varepsilon \tag{5.11}$$

In the equation above, Δ is the first difference operator. q is investment opportunity; cash flow is operating revenue($\pi(k,c)$). Size is firm size that we calculate with $ln(k_{i,t})$. This is the equation estimated by Almeida et al. (2004), and also studied by Riddick and Whited (2009).

We measure q with two methods. Firstly we use $V_{i,t}/k_{i,t}$ as the measurement of q, where $V_{i,t}$ is the firm's value, which can be simulated with value function iteration directly. We also use productivity growth (demand growth) which is defined as $\Delta ln(Z_t)$ in Bloom et al. (2007).

To compare the differences between the two types of precautionary savings, we estimate Equation 5.11 with two groups of simulated data. We firstly estimated the data without ambiguity aversion and low adjustment costs.

Table 5.1: Estimation on simulated data: type 1 precautionary saving

	(1)	(2)	(3)	(4)	(5)	(6)
	$\Delta Cash$	$\Delta Cash$	$\Delta Cash$	investment	investment	investment
q	0.0654***			-0.511***		
	(0.00079)			(0.0049)		
$\Delta ln(Z_t)$		0.0653***			0.497***	
		(0.00125)			(0.00216)	
$\frac{Cashflow_{i,t}}{c_{i,t}+k_{i,t}}$	-0.106***	-0.603***	-0.262***	2.595***	1.222***	3.815***
	(0.00452)	(0.00554)	(0.00468)	(0.00957)	(0.0112)	(0.0103)
Size	0.0863***	0.0363***	0.00307***	-0.903***	0.000595	-0.253***
	(0.00111)	(0.00052)	(0.0005)	(0.006)	(0.0014)	(0.00124)
Observations	190,000	190,000	190,000	190,000	190,000	190,000
R-square	0.08	0.064	0.041	0.730	0.614	0.472

Notes: we estimate the equation (5.11) with OLS method. The data are simulated from the model of theoretical framework with adjustment cost $g = 0.049$. The results are reported in column (1) (2) and (3). q is average q or Tobin's q calculated from $V_{i,t}/k_{i,t}$, where $V_{i,t}$ is firm's value. $\Delta ln(Z_t)$ is the productivity or demand shock. Cash flow is defined the ratio of cash flow to total assets and size is the logarithm of total assets. The dependent variable in Column (4) (5) and (6) is investment. We estimate investment regressions for robustness reasons.

We simulate a panel of 10,000 firms and 20 years with low adjustment cost ($g = 0.049$) and no ambiguity aversion ($a = 0$). We capture the investment opportunity with both Tobin's q and demand shocks ($\Delta ln(Z_t)$). Columns (1) (2) and (3) report the cash-cash flow sensitivity. We find that both q and $\Delta ln(Z_t)$ have a positive impact on savings policy and the cash-cash flow sensitivities are negative given different types of investment opportunities. We want to check whether the model is well defined and q is well measured. So, we estimate firm investment with investment opportunity and cash flow for robustness [11]. The results are reported in columns (4) (5) and (6). In column (4) we find that the coefficient of q is negative. Therefore we have reason to suspect that the q is mismeasured with this method.

Then we use demand growth. In column (5) we find that investment shows positive respond to demand shocks. We also remove investment opportunity and the results are reported in column (3) and (6). We find that investment-cash flow sensitivity is

[11] Investment is investment to total asset ratio.

positive.

Table 5.2: Estimation on simulated data: type 2 precautionary savings

	(1) $\Delta Cash$	(2) $\Delta Cash$	(3) $\Delta Cash$	(4) investment	(5) investment	(6) investment
q	-0.0710***			-0.479***		
	(0.000648)			(0.00156)		
$\Delta ln(Z_t)$		0.101***			0.0798***	
		(0.000346)			(0.000694)	
$\frac{Cashflow_{i,t}}{c_{i,t}+k_{i,t}}$	0.510***	0.0304***	0.380***	1.857***	0.706***	0.981***
	(0.00186)	(0.00109)	(0.00125)	(0.00285)	(0.00410)	(0.00389)
Size	-0.145***	0.00189***	-0.0506***	-0.701***	-0.0221***	-0.0634***
	(0.00111)	(0.00052)	(0.0005)	(0.006)	(0.0014)	(0.00124)
Observations	190,000	190,000	190,000	190,000	190,000	190,000
R-square	0.313	0.563	0.256	0.847	0.397	0.361

Notes: we estimate the equation (5.11) with OLS method. The data are simulated from the model of theoretical framework with adjustment cost $g = 0.455$. The results are reported in column (1) (2) and (3). q is average q or Tobin's q calculated from $V_{i,t}/k_{i,t}$, where $V_{i,t}$ is firm's value. $\Delta ln(Z_t)$ is the productivity or demand shock. Cash flow is defined the ratio of cash flow to total assets and size is the logarithm of total assets. The dependent variable in Column (4) (5) and (6) is investment. We estimate investment regressions for robustness reasons.

Then we simulate another panel with ambiguity aversion ($a = 0.5$) and high adjustment cost (g=0.455). We find that with ambiguity aversion (in Table 5.2), cash-cash flow sensitivity is positive.

The trade-off theory suggests that given the costs and benefits of holding liquid assets, firms tend to rebalance their cash holding towards a target level which maximizes shareholder wealth. Our results in Table 5.2 are consistent with the theory. Firms save money because they worry about the shortage of liquidity in future. The shortage is not only caused by good opportunities but also by bad shocks.

5.4 Data

5.4.1 The dataset

We use the universe of listed Chinese firms that issue A-shares on either the Shanghai Stock Exchange (SHSE) or the Shenzhen Stock Exchange (SZSE) during the period 1998-2010, which is obtained from the China Stock Market Trading Database (CSMAR) and China Economic Research Service Centre (CCER). Following the literature, we exclude firms in the financial sector. Furthermore, to minimize the potential influence of outliers, we drop 1% for the key regression variables. Finally, we drop all firms with less than three years of consecutive observations. All variables are deflated using the gross domestic product (GDP) deflator (National Bureau of Statistics of China).

Originally, there are 19,360 observations. We drop the observations with negative sales, total assets minus total fixed assets, total assets minus liquid assets [12]. There are 20 observations dropped. We then dropped all the financial firms. There are 98 observations deleted. Then we drop 1% outliers of main regression variables. We have 14,937 observations left. With number of observations varying from a minimum of 650 in 1998 to a maximum of 1,505 in 2008.

[12]In Chapter three and four, we also dropped the accumulated depreciation minus current depreciation. However, in listed firm dataset, the accumulated depreciation is not available.

5.4.2 Summary statistics

Table 5.3: summary statistics

VARIABLES	N	mean	S.D.	p25	p50	p75
$Cash/A$	14,927	0.154	0.113	0.073	0.128	0.208
$\Delta Cash/A$	14,312	0.00555	0.0880	-0.0314	0.00358	0.0431
q	14,927	1.593	0.823	1.076	1.314	1.795
$Cashflow/A$	14,927	0.0486	0.0885	0.0059	0.0468	0.0926
Leverage	14,805	0.235	0.197	0.109	0.220	0.331
Δy	14,271	0.092	0.475	-0.0545	0.0943	0.250
$CAPEX/A$	14,927	0.0586	0.0613	0.0146	0.0392	0.0816
$CAPSALE/A$	14,927	0.00428	0.0152	6.6e-05	0.000372	0.00194
Size	14,927	20.52	1.066	19.81	20.42	21.14

Notes: the table reports means, standard deviations, and distributions of key variables. Cash is cash holdings; A is total assets; Tobin's q is the market to book ratio. cash flow is cash flow to total assets. Δy is sales growth. $CAPEX/A$ is defined as the ratio of the capital expenditures to total assets. $CAPSALE/A$ is defined as the ratio of the capital sales to total assets. Leverage is the ratio of the sum long-term debts and short-term borrowings to total assets

The Table 5.3 above reports the means median and distributions of key variables. We can find that on average cash holdings to total asset ratio is 0.154, which is far higher than cash flow. We also check the leverage ratio, we find that on average Chinese listed firms' debt is higher than cash holdings. It suggests that firms save and borrow together. The average value of $CAPSALE/A$ is very low. And, the median value is only 0.000395, which is far smaller than cash flow. For most firms, liquidation is not an important source of finance.

Table 5.4: Means in different years

year	N	$Cash/A$	$\Delta Cash/A$	$Cashflow/A$	q	Leverage	Δy	$CAPEX/A$	$CAPSALE/A$	Size
1998	650	0.107		0.0228	1.362	0.217		0.0548	0.00331	20.11
1999	781	0.128	0.0207	0.0357	1.462	0.231	0.0941	0.0477	0.00271	20.22
2000	877	0.157	0.0238	0.0443	1.850	0.233	0.115	0.0524	0.00315	20.36
2001	965	0.173	0.079	0.0457	1.601	0.236	0.0740	0.0637	0.00381	20.43
2002	1,061	0.163	-0.00942	0.0503	1.390	0.242	0.119	0.0606	0.00405	20.47
2003	1,142	0.159	0.0032	0.0461	1.245	0.254	0.152	0.0663	0.00454	20.55
2004	1,219	0.155	-0.0129	0.0508	1.135	0.260	0.127	0.0666	0.00447	20.52
2005	1,181	0.141	-0.0150	0.0535	1.063	0.259	0.0266	0.0607	0.00457	20.53
2006	1,257	0.143	0.0009	0.0585	1.286	0.253	0.0681	0.0555	0.00467	20.57
2007	1,456	0.154	0.0129	0.0462	2.134	0.225	0.121	0.0570	0.00532	20.53
2008	1,505	0.155	-0.00815	0.0497	1.333	0.226	0.0037	0.0634	0.00510	20.48
2009	1,494	0.170	0.0322	0.0644	2.198	0.216	0.0360	0.0528	0.00405	20.71
2010	1,339	0.170	0.0176	0.0423	2.267	0.208	0.216	0.0556	0.00412	20.86

Notes: the table reports means, standard deviations, and distributions of key variables. N is number of observations. Cash is cash holdings; A is total assets; Tobin's q is the market to book ratio. cash flow is cash flow to total assets. Δy is sales growth. $CAPEX/A$ is defined as the ratio of the capital expenditures to total assets. $CAPSALE/A$ is defined as the ratio of the capital sales to total assets. Leverage is the ratio of the sum long-term debts and short-term borrowings to total assets

Table 5.4 reports the means of key variables in different years. The table shows some very interesting patterns. We can find that firms hold more cash in 2010 and the cash holdings increased since 2006. Chen et al. (2012) point out that increasing financial market efficiency could decrease cash holding. They find that Chinese-listed firms have decreased cash holding level significantly after the 2005-2006 split share structure reform. Non-tradable shares holding by controlling shareholders became tradable after the reform. The reform removes a significant market friction and relaxes firms' financing constraints. This could be used to explain why cash holdings decreased in 2006. However, the leverage ratio decreased since 2006. Sales growth of Chinese listed firms dropped to almost 2% in 2008 and then in 2010 we find a strong recovery of the demand side.

Table 5.5: Sales growth, Tobin's q and cash holdings

Sales Growth	Mean Savings	Tobin's q	Mean Savings
Low	0.132	Low	0.134
Medium low	0.151	Medium low	0.150
Medium high	0.155	Medium high	0.161
High	0.174	High	0.171

Notes: We split our sample to subsamples with sales growth and Tobin's q from low to high. Sales growth is Low if sales growth falls below the 25th percentile of the distribution; Sales growth is Medium low if sales growth falls between the 25th percentile and 50th percentile of the distribution; Sales growth is Medium high if sales growth falls between the 50th percentile and 75th percentile of the distribution; and Sales growth is High if sales growth falls above the 75th percentile of the distribution. We also classify Tobin's q according to this rule.

In Table 5.5, we calculate the mean value of savings regarding sales growth and Tobin's q, from low to high. We find that whichever index we use, firms save more in good time (high sales growth or high q). This gives us an intuitive idea, that type 2 precautionary savings may play a more important role.

5.5 Empirical methodology

There are many papers which show that corporate liquidity helps firms to solve financing constraint problems because external financing cost is high. They call them 'precautionary saving'. However, to our best knowledge, few paper explicitly explain though which channel firms save their money precautionarily. As such, we introduce a confidence shock and ambiguity aversion with a simple dynamic structural model above. We need to show some empirical evidence to prove that these channels are essential.

Using simulated method of moments (SMM), we can directly estimate the parameters such as γ, ρ, g, a, b, and σ by minimising the distance between simulated and empirical moments. However, there is a key limitation of using this method. Firstly, in our model cash flow is simply assumed as a result of production function based on technology shock and capital. This result is non-negative (also mentioned by Riddick and Whited (2009)). However, in our data set, cash flow is defined more specifically[13]. There are also a large proportion of firm-years which have negative cash flow. This will make the estimation process difficult and less precise [14].

To find out how firms make their cash holding decisions under uncertainty, we try to find empirical evidence in two perspectives: the cash flow sensitivity of cash and value of cash holdings.

5.5.1 Uncertainty and cash flow sensitivity of cash

One of our primary objectives is to find how cash holdings respond to cash flow. When firms decide to spend and save money is important. As we specified above, the first type of precautionary savings suggest that firms save during bad times to use in good times, so we expect a negative relationship between cash flow and cash. However, if external financing costs are high and firms are not confident with future, we then expect a positive cash flow sensitivity of cash.

The regression model is:

$$\frac{\Delta Cash_{i,t}}{A_{i,t}} = \beta_0 + \beta_1 q_{i,t} + \beta_2 \frac{Cashflow_{i,t}}{A_{i,t}} + \beta_3 size_{i,t} + v_i + v_t + vj + v_{j,t} + e_{i,t} \quad (5.12)$$

Where $\Delta Cash$ is the first difference of cash holdings [15]; A is total asset; q is the measurement of investment opportunity. Here we use Tobin's q and sales growth (Δy) as the proxy. This is because Tobin's q may involve mismeasurement problem.

[13] Operating Cash Flow=Cash Received From Sales Of Goods Or Rendering Of Services+Net Increase In Customer Deposit And Due To Banks And Other Financial Institutions+Net Cash Borrowing From Central Banks+Increase In Placements From Other Financial Institutions+Premiums Received +Net Cash Received From Reinsurance+Increase In Policyholders Deposit And Investment +Cash Received From Disposal Of Trading Financial Assets +Interests, Fees And Commissions Received+Increase In Placement From Bank And Other Financial Institutions +Increase In Repo +Tax Refund +Other Cash Received Relating To Operating Activities -Cash Paid For Goods And Services -Increase In Loan To Customers -Net Increase In Due From Central Bank And Financial Institutions -Claims Paid -Interests; Fees And Commissions Paid -Policy Dividends Paid -Cash Paid To And On Behalf Of Employees -Various Taxes Paid -Other Cash Paid Relating To Operating Activities

[14] Please find the results of SMM in the appendix.

[15] In regression, the dependent variable is the first difference of cash, but not the level of cash. There is no theoretical reason suggests that the change of cash follows an AR(1) process. Also, many papers have shown that the dynamic model is not necessary in this topic, for example, Almeida et al. (2004) and Tsoukalas et al. (2016).

$Cashflow/A$ is operating cash flow over total assets. In the data set, there are three types of cash flows, namely operating cash flow, investment cash flow and financial cash flow. Generally speaking, investment cash flow is the cash inflow minus cash out flow of investing activities, such as trading financial fixed, or intangible assets. Financial cash flow is net cash flow form financial activities, such as issuing bonds, equities or payment of dividends and interests. In the theatrical framework, we assume that firm's cash flow is specifically, it is only determined by productivity and capital. This means we only consider the cash flow from operating activities.

size is the natural log of total assets.There are five types of error terms: (1) firm specific time invariant effects (v_i); (2) time specific effects (v_t); (3) industry specific effects (v_j); (4) time specific and industry specific effects (v_{jt}), which are used to capture industry specific business cycles. (5) an idiosyncratic error (e_{it}).

Table 5.6: Cash flow sensitivity of cash (full sample)

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	OLS	FE	GMM	OLS	FE	GMM
q	0.00162	0.00546***	0.0192***			
	(0.00122)	(0.00142)	(0.00405)			
Δy				0.0271***	0.0237***	0.0135
				(0.00264)	(0.00160)	(0.0141)
$Cashflow/A$	0.278***	0.332***	0.187**	0.261***	0.318***	0.325***
	(0.0171)	(0.00933)	(0.0952)	(0.0167)	(0.00935)	(0.102)
size	0.00924***	0.0313***	0.00578**	0.00684***	0.0245***	0.00135
	(0.000876)	(0.00186)	(0.00256)	(0.000727)	(0.00173)	(0.00262)
Observations	14,312	14,312	14,312	14,271	14,271	14,271
R-squared	0.139	0.156		0.155	0.166	
m1			0			0
m3			0.359			0.229
Hansen test			0.0250			0.0228

Notes: q is Tobin's q, the ratio of market value over booked; Δy is sales growth. $Cashflow/A$ is the ratio of cash flow to total assets. Columns (3) and (6) report the results estimated with system GMM. Levels of all regressors lagged two times and longer are used as instruments in the first-differenced equations. First-differenced variables lagged once are used as additional instruments in the level equations. Time dummies, industry dummies, and time interacted with industry dummies are included.

Column (1) and (2) in Table 5.6 show a positive cash-cash flow sensitivity which is close to Almeida and Capello (2004) using OLS and Fixed-Effect estimation methods. The system GMM estimator (Blundell and Bond, 1998) is also used to estimate the equation and its variants in order to take into account unobserved firm heterogeneity and the possible endogeneity and mismeasurement problems of the regressors. Levels of all regressors lagged two times and longer are used as instruments in the first-differenced equations. First-differenced variables lagged once are used as additional instruments in the level equations. Time dummies, industry dummies, and time interacted with industry dummies are included. In assessing whether our instruments are legitimate and our models are correctly specified, the Hansen J test of over-identifying restrictions is employed to evaluate the overall validity of the set of instruments. However, the estimation results with different methods are consistent with each other. In columns (4) (5) and (6), we use sales growth as the proxy of investment opportunities. This is because Tobin's q (average q) involves mismeasurement problems. We find the cash flow sensitivity of cash is not significantly changed.

The difference between Almeida et al. (2004) and our result is that they suggest that more constrained firms show higher cash-cash flow sensitivity, but our focus is on uncertainty.

In the theoretical model, we predict that without uncertainty, firms do not have incentive to hold cash. Therefore, we expect that uncertainty can increase firm's cash holdings. In addition, we point out two channels that uncertainty triggers precautionary savings as we discussed above. As we predicted, if a firm want to hold cash to hedge uncertain cash flow shortfalls, there will be a positive cash-cash flow sensitivity. To empirically test the main channel though which uncertainty affects savings, the equation we estimate is as follows:

$$\begin{aligned}\frac{\Delta Cash_{i,t}}{A_{i,t}} = \beta_0 + \beta_1 q_{i,t} + \beta_2 \frac{Cashflow_{i,t}}{A_{i,t}} + \beta_3 size_{i,t} + \beta_4 SD_{i,t} \\ + \beta_5 \frac{Cashflow_{i,t}}{A_{i,t}} * SD_{i,t} + v_i + v_t + vj + v_{j,t} + e_{i,t}\end{aligned} \tag{5.13}$$

To precisely link with our theoretical model, in the equation above, we include the variable $SD_{i,t}$ which is a proxy of uncertainty and an interaction term $\frac{Cashflow_{i,t}}{A_{i,t}} * SD_{i,t}$. If the coefficient of SD_it is positive, it means uncertainty can increase cash holdings. More importantly, the interaction term is to capture how uncertainty affects cash-cash flow sensitivity. If the manager is averse to uncertainty, as we predicted in our theoretical model, the coefficient of the interaction term should be positive. In other words, managers want to save more during good times and hedge the bad shocks.

Table 5.7: Cash holdings and uncertainty

	(1)	(2)	(3)	(4)
q	0.0140***	0.0143***	0.0141***	0.0151***
	(0.00390)	(0.00381)	(0.00384)	(0.00379)
$Cashflow/A$	0.279***	0.150*	0.256***	0.185**
	(0.0750)	(0.0883)	(0.0715)	(0.0878)
SD1	0.0242*	0.0103		
	(0.0145)	(0.0143)		
$Cashflow/A$*SD1		0.381**		
		(0.177)		
SD2			0.00540	-0.00504
			(0.0252)	(0.0260)
$Cashflow/A$*SD2				0.359*
				(0.198)
size	0.0310***	0.0307***	0.0319***	0.0316***
	(0.00227)	(0.00227)	(0.00236)	(0.00235)
Observations	10,363	10,363	9,874	9,874
m1	0	0	0	0
m3	0.884	0.528	0.937	0.477
J test	0.205	0.242	0.0817	0.0541

Notes: q is Tobin's q, the ratio of market value over booked; $Cashflow/A$ is the ratio of cash flow to total assets. SD1 and SD2 are proxies of uncertainty. Size is the logarithm of total assets. The regressions are estimated with System GMM method. Levels of all regressors lagged three and four times are used as instruments in the first-differenced equations. First-differenced variables lagged twice are used as additional instruments in the level equations. Time dummies, industry dummies time interacted with industry dummies are included.

The Table 5.7 estimated the relationship between cash holdings and cash flow under uncertainty[16]. More specifically, we want to find from which channel uncertainty can affect cash holdings. SD1 is the proxy for uncertainty [17]. The estimation method is

[16] Please find the results estimated with OLS method in Table 5.E.1.

[17] We empirically measure the uncertainty by estimating a first-order panel autoregression of oper-

system GMM. We use levels of all regressors lagged three and four times as instruments in the first-differenced equations and first-differenced variables lagged twice as instruments in the level equations. Time dummies, industry dummies time interacted with industry dummies are included. Column (1) shows that uncertainty has a positive impact on savings. So firms will hold more cash if the income uncertainty is high, this is consistent with the type one precautionary savings in our theoretical hypothesis. In column (2) we add an interaction term, '$Cashflow/A * SD1$'. We find that the result is significant and positive. This means high uncertainty can increase the sensitivity. Firms with high uncertainty will save more cash when cash flow is high. The result shows some evidence of type two precautionary savings. Column (3) and (4) use $SD2$ to measure uncertainty, which is the two-year standard deviations of error term ($t-1$, t). The results are very close to $SD1$ [18].

As already discussed, the positive coefficients of interaction term suggest that there is a positive relationship between uncertainty and cash-cash flow sensitivity. Almeida et al. (2004) do not accounted for uncertainty, and Riddick and Whited (2009) do not link the cash-cash flow sensitivity to uncertainty. The uncertainty term is economically important. The mean of SD1 is 0.23, and the coefficient of '$Cashflow/A * SD1$' is 0.381 in column (2). Thus, on average, uncertainty term can increase cash-cash flow uncertainty by 0.0876[19].

5.5.2 Value of cash holdings and uncertainty

So far, we find that cash-cash flow sensitivity is positive in China and also high uncertainty can lead to a higher sensitivity. We need to know whether or not uncertainty can make firms hold more excess cash. This is important to distinguish which type of precautionary saving is more important and dominant. Since the type one precautionary savings suggests that firms only need to save during bad times and do not need to save much in good times. The value of cash will be very high because the money will be invested only to good projects with good returns. On the other hand, the type two precautionary savings' value will be low. Since firms want to use cash to hedge

ating income by using system GMM. And, the SD1 value is the standard deviation of error term of three years ($t-2$, $t-1$, t). Please find the estimation results in the appendix.

[18]We also report the results estimated with Fixed Effects in Table 5.E.1

[19]In column (4), mean of SD2 is 0.20 and the coefficient of '$Cashflow/A * SD2$' is 0.359. The average impact of uncertainty on cash-cash flow sensitivity is 0.718.

unexpected income shocks, managers will hold more excess cash.

Estimating how uncertainty affect the value of cash is also important to test confidence shocks. If a firm is not confident with their future, firms will hold more cash and uncertainty can have a larger impact on the value of cash reserves than confident firms.

To measure the impact of uncertainty on the value of cash holdings, we use the method suggested by Faulkender and Wang (2006), and Dittmar and Mahrt-Smith (2007). The method is to test whether a change in cash holdings can change firm value. The change in firm value is measured by the excess return for firm i during year t less the return of market portfolio of China year t [20]. Since the dependent variable is the change in equity value, in the regression we also need to control changes in a firm's profitability, financing policy, and investment policy. Based on the framework of Faulkender and Wang (2006) and Dittmar and Mahrt-Smith (2007), we add uncertainty into the regression, which could be written as:

$$\begin{aligned} r_{i,t} - R_t^M = \gamma_0 &+ \gamma_1 \frac{\Delta Cash_{i,t}}{MV_{i,t-1}} + \gamma_2 \frac{\Delta E_{i,t}}{MV_{i,t-1}} + \gamma_3 \frac{\Delta NA_{i,t}}{MV_{i,t-1}} + \gamma_4 \frac{\Delta D_{i,t}}{MV_{i,t-1}} \\ &+ \gamma_5 \frac{Cash_{i,t}}{MV_{i,t-1}} + \gamma_6 L_{i,t} + \gamma_7 \frac{NF_{i,t}}{M_{i,t-1}} + \gamma_8 \frac{Cash_{i,t-1}}{MV_{i,t-1}} * \frac{\Delta Cash_{i,t}}{MV_{i,t-1}} \\ &+ \gamma_9 L_{i,t} * \frac{\Delta Cash_{i,t}}{MV_{i,t-1}} + \gamma_{10} SD_{i,t} * \frac{\Delta Cash_{i,t}}{MV_{i,t-1}} + v_i + v_t + vj + v_{j,t} + e_{i,t} \end{aligned} \tag{5.14}$$

where, ΔX indicates a change in X from year $t-1$ to t. $r_{i,t}$ =Annual Return with Cash Dividend Reinvested, R_t^M =Annual Market Return with Cash Dividend Reinvested, $MV_{i,t}$ =Market Value of Equity +Market Value of Net debt, $E_{i,t}$=Earnings before Extraordinary (EBIT) between time $t-1$ and t, $NA_{i,t}$=Net Tangible Asset at time t, $D_{i,t}$ =Cash Paid For Distribution Of Dividends Or Profits Or Cash Paid For Interest Expenses, $L_{i,t}$=Leverage Ratio, $NF_{i,t}$=Net Cash Flow From Financing Activities, $SD_{i,t}$ is the proxy of uncertainty. The control variable are very close to, but not the same as, Faulkender and Wang (2005), and Dittmar et al. (2007) because we use a different dataset [21]. Their regression is estimated as ordinary least squares (OLS). Since the right-hand-side variables can be endogenous, we use system GMM

[20]The return of market portfolio in our data set is annual market returns with cash dividend reinvested (total-value-weighted).

[21]Please find more detailed summary statistics of the key variables in the regression in Table 5.D.1 in the appendix

method[22].

This regression enables us to test the relationship between cash and uncertainty and link to our theoretical predictions in the perspective of equity value. When there is no agency problem, a firm hold one more dollar of cash will also increase its equity value by one dollar (Faulkender and Wang, 2006). If the equity value increase less than one dollar, it means managers hold excess cash. In our theoretical model, we predict that when managers are not confident and uncertainty is high, they will hold more cash. To test how excess cash related to uncertainty, we focus our analysis to the interaction term between uncertainty and change in cash. If the coefficient of the interaction term is negative, it means uncertainty will cause managers hold more excess cash and lower the value of cash.

Table 5.8 reports the estimation results of the Equation (5.14) with full sample. The method we use is system GMM. Levels of all regressors lagged three times and longer are used as instruments in the first-differenced equations[23]. First-differenced variables lagged twice are used as additional instruments in the level equations. $SD1$ and $SD2$ are the standard deviations of error term of three and two years respectively. The results of column (1) and (2) are very close. In Column (1) the coefficient of the change in cash holdings suggests that an extra dollar of cash is valued by shareholders at 1.161 dollars. The coefficient of $Cash_{i,t-1}/MV_{i,t-1} * \Delta Cash/MV_{i,t-1}$ is not significant. So, there is no evidence that a high cash holding level is detrimental to the value of cash holdings on aggregate level.

However, we find that the interaction term $SD1 * \Delta Cash/MV_{i,t-1}$ and $SD2 * \Delta Cash/MV_{i,t-1}$ has a significant negative impact on the value of cash holdings. This means firms will hold more excess cash when uncertainty is high, but shareholders think that the marginal cash value will be lower since holding more excess cash is costly. As the result, the marginal value calculated from Column (1) and (2) are \$0.520 and \$0.573 [24]. The average marginal value of corporate cash holdings from 1971 to 2001 in US is 0.94 (Faulkender and Wang, 2006, see). The results suggest that Chinese firms hold

[22] Please find more discussion of system GMM in section 3.33. The estimates of OLS are reported in Table 5.E.2.

[23] We also estimate the regression with OLS method. The results are reported in the appendix, Table 5.E.2.

[24] The means of SD1 and SD2 are 0.231 and 0.204 respectively. The value \$0.520=\$0.636-(0.503*0.231); \$0.573=0.6576-(0.416*0.204). The impact of uncertainty is also economically significant.

more excess cash than US.

Table 5.8: Cash holdings and uncertainty

VARIABLES	(1)	(2)
$\Delta Cash/MV_{i,t-1}$	0.636**	0.657**
	(0.302)	(0.292)
$\Delta E/MV_{i,t-1}$	1.844***	1.909***
	(0.179)	(0.188)
$\Delta NA/MV_{i,t-1}$	-0.0612	-0.0935
	(0.0754)	(0.0673)
$\Delta D/MV_{i,t-1}$	0.0222	0.0767
	(0.520)	(0.508)
$Cash/MV_{i,t-1}$	0.316***	0.341***
	(0.0854)	(0.0873)
$Cash_{i,t-1}/MV_{i,t-1} * \Delta Cash/MV_{i,t-1}$	1.209	1.147
	(1.344)	(1.302)
$Leverage * \Delta Cash/MV_{i,t-1}$	-0.878	-0.892
	(0.706)	(0.733)
$leverage$	0.164***	0.190***
	(0.0452)	(0.0500)
$SD1 * \Delta Cash/MV_{i,t-1}$	-0.503***	
	(0.160)	
	(0.339)	
$SD2 * \Delta Cash/MV_{i,t-1}$		-0.416***
		(0.122)
$NF/MV_{i,t-1}$	-0.0879	-0.130
	(0.101)	(0.0928)
Observations	10,154	9,679
m1	0	0
m3	0.118	0.129
J test	0.000291	0.000522

Notes: The regressions are estimated with System GMM method. Levels of all regressors lagged three and four times are used as instruments in the first-differenced equations. First-differenced variables lagged twice are used as additional instruments in the level equations. Time dummies, industry dummies time interacted with industry dummies are included.

Table 5.9: Cash values and uncertainty

VARIABLES	(1) SOEs	(2) Private	(3) Diff	(4) Before Crisis	(5) After Crisis	(6) Diff
$\Delta Cash/MV_{i,t-1}$	0.522**	1.142**	0.3367	0.358	1.355***	0.0590*
	(0.228)	(0.481)		(0.290)	(0.270)	
$\Delta E/MV_{i,t-1}$	1.647***	2.605***	0.0594*	2.047***	1.416***	0.0560*
	(0.107)	(0.199)		(0.114)	(0.153)	
$\Delta NA/MV_{i,t-1}$	-0.158***	-0.0467	0.5646	-0.0634	-0.203**	0.3597
	(0.0557)	(0.124)		(0.0626)	(0.0918)	
$\Delta D/MV_{i,t-1}$	0.142	-1.078	0.4072	0.652	-2.364***	0.0027***
	(0.408)	(1.113)		(0.479)	(0.667)	
$Cash/MV_{i,t-1}$	0.243***	0.136	0.6138	0.327***	0.324***	0.9841
	(0.0914)	(0.191)		(0.103)	(0.120)	
$Cash_{i,t-1}/MV_{i,t-1} * \Delta Cash/MV_{i,t-1}$	2.324***	-3.320*	0.0165**	2.557***	-4.042***	0.0003***
	(0.726)	(1.766)		(0.950)	(1.054)	
$Leverage * \Delta Cash/MV_{i,t-1}$	-0.367	-1.165	0.5411	-1.490**	0.521	0.1336
	(0.588)	(0.989)		(0.650)	(0.683)	
$leverage$	0.155***	0.0684	0.1653	0.191***	0.134**	0.4893
	(0.0476)	(0.0597)		(0.0428)	(0.0577)	
$SD1 * \Delta Cash/MV_{i,t-1}$	-0.399***	-1.030***	0.10*	-0.394**	-0.509***	0.6855
	(0.120)	(0.320)		(0.165)	(0.154)	
$NF/MV_{i,t-1}$	-0.0875	0.159	0.395	0.0760	-0.301***	0.0351**
	(0.0735)	(0.163)		(0.0899)	(0.0889)	
Observations	6,668	2,306		6,398	3,756	
R-squared	0.328	0.350		0.287	0.281	

Notes: To be consistent with Faulkender and Wang (2006), and Dittmar and Mahrt-Smith (2007), the regressions are estimated with OLS for robustness. Also we split the sample. The subsample 'after crisis' has only 3 year observations (2008-2010). GMM cannot be applied to this situation. Diff is the p-value associated with the t-test for differences in coefficients of corresponding variables between SOEs and private firms and the samples before and after the crisis. ***, ** and * indicate significance at the 1%, 5% and 10% levels respectively.

In Table 5.9, we split the data into sub-samples by ownership and the sub-prime crisis. The ownership depends on the nature of ultimate shareholder from CCER. Therefore, a firm is state owned if the ultimate shareholder is government, and private if the firm is owned by private shareholders. In column (1) and (2), we find that the interaction term, $SD1 * \Delta Cash/MV_{i,t-1}$, can significantly decrease the cash value of state owned firms. This suggests that both SOEs and private firms will hold more excess cash when uncertainty is high. It also indicate that private firms are more averse to uncertainty. In addition, shareholders of private firms show a strong negative respond to a high cash holding rate. This finding is consistent with Jensen (1986), that managers have an incentive to hold more cash than investors. The result is both economically significant and economically significant: the mean value of $SD1$ of private firms is 0.276. It can decrease marginal market value of cash holdings by \$0.276. However, the impact of uncertainty on the marginal market value of cash holdings is only \$0.0838 for SOEs.

Finally, we can calculate the cash value with the method suggested by Faulkender and Wang (2006). The cash value of SOEs is \$0.470[25], and the value of private firms is \$0.429 [26].

Column (3) and (4) report the result estimated with the sample before the sub-prime crisis (2000-2007), and after the crisis (2008-2010). We find that after the crisis, shareholders value savings more, but earnings less. The coefficient of $\Delta Cash/MV_{i,t-1}$ after the crisis is much higher than the coefficient before the crisis. This may be because firm managers are more averse to uncertainty after financial crisis. Holding more cash during after the crisis for precautionary reasons can help firms hedge income shocks. This is also consistent with our theoretical prediction.

The coefficient of interaction term $Cash_{i,t-1}/MV_{i,t-1} * \Delta Cash/MV_{i,t-1}$ after financial crisis is significantly negative. Managers may hold more excess cash because of agency problem. Uncertainty have higher negative impact on cash holdings especially after the crisis. However, the result is not statistically significant.

5.6 Conclusion

This chapter develops a dynamic model taking financing constraints, uncertainty, adjustment costs and confidence shocks into consideration. We find two different types of precautionary savings. The first type is saving money in bad times to use in good times in order to maximise firms' profit if external finance is costly. The second type is save in good times to use in bad times. This is to hedge the unexpected income shocks in future. Based on two different types of precautionary savings, we find contrary arguments on cash flow sensitivity of cash.

We also find evidence of precautionary savings with real data. We use the data set of Chinese listed firms and we find a positive cash-cash flow sensitivity. Uncertainty can make firms save more and have higher cash-cash flow sensitivity. We then use the

[25]Means SD1, and $Cash_{i,t-1}/MV_{i,t-1}$ of SOEs are 0.210 and 0.132, \$0.470=0.522+0.243*0.132-0.399*0.210)

[26] Means of SD1 and $Cash_{i,t-1}/MV_{i,t-1}$ of private firms are 0.276 and 0.129,\$0.429=1.142-3.32*0.129-1.03*0.276.

method suggested by Faulkender and Wang (2006) to calculate the market value of cash under uncertainty. We find that the marginal market value of cash holdings will decrease if uncertainty increases. This suggests that high uncertainty leads firms to save more excess cash. This is consistent with our ambiguity aversion hypothesis. We also find that uncertainty has a larger impact on the value of cash in the post-crisis period than before the crisis. This suggests that firms are more averse to uncertainty after the financial crisis.

The findings suggest that firms hold cash precautionarily not only because of financing constraints and uncertainty. The attitude towards uncertainty (ambiguity aversion) is also important. Another contribution is that we reconcile the results of the contrary arguments on cash flow sensitivity of cash.

Holding too much cash can be costly. In this chapter, we find that marginal market value of cash holdings of the firms in China is less than in US. To encourage firm managers hold less cash, policymakers can: first, decrease uncertainty, and strengthen manager's confidence; second, further reform the financial system in China and enable managers use more financial instruments to hedge uncertainty.

Appendix

5.A Measurement of uncertainty

The uncertainty is measured with 3-year moving standard deviation of the unpredictable operating income (SD1), which is the income of sales of goods and services. For robustness, we also use a 2-year moving standard deviation. We follow the method suggested by Caglayan et al. (2012). We estimate an AR(1) model of the logarithm of sales augmented with time and industry-time specific dummies. The result is reported as:

Table 5.A.1: Cash values and uncertainty

Dependent Variable	$ln(y_t)$
$ln(y_{t-1})$	0.829***
	(0.0908)
Observations	9874
m1	0
m2	0.748
J test	0.771

Notes: The regressions are estimated with system GMM. Level of the regressor lagged two times and longer are used as instruments in the first-differenced equations. First-differenced variable lagged once are used as additional instruments in the level equations.

The instruments we use are the dependent variable lagged by 2 and 3. The null hypotheses of both m2 test and Hansen test (J test) are not rejected [27].

[27] m2 is a test for second-order serial correlation of the differenced residuals, asymptotically dis-

For robustness we also compared the firm specific income uncertainty with policy uncertainty measured by Baker et al. (2013). The policy uncertainty is calculated and collected by Nick Bloom. To measure economic policy uncertainty for China, we construct a scaled frequency count of articles about policy-related economic uncertainty in the South China Morning Post (SCMP), Hong Kong's leading English-language newspaper[28].

They report uncertainty with monthly time series data. However, time specific errors are already removed from our regressions. So policy uncertainty is not included in our regressions.

Also there are methods based on the volatility of stock market returns (e.g. Bo and Lensink, 2005 and Bloom et al, 2007). However, currently I do not have easy access to stock market trading data, but maybe in the future I will use these methods.

We also calculated average value of firm specific income uncertainty (SD1) by year.

Figure 5.A.1: Policy uncertainty and firm specific income uncertainty

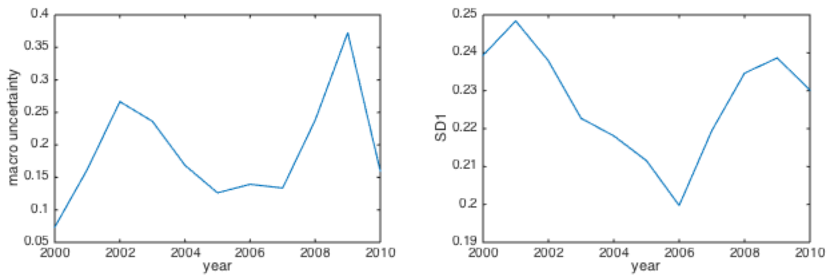
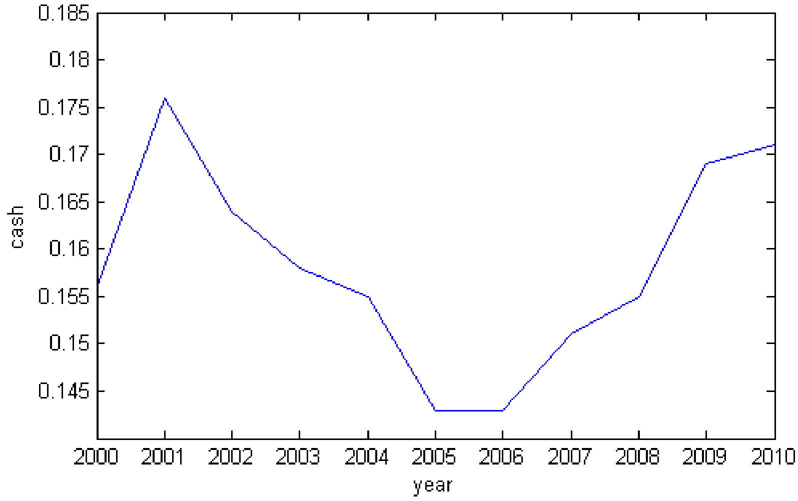


Figure 5.A.1 reports the two uncertainties. The figure on the left hand side plots policy uncertainty and on the right hand side plots firm income uncertainty. Generally, both types of uncertainty is high around the period 2001 -2002 and 2007-2009. Uncertainty decreases from 2010. There are also some differences. We can find that policy uncertainty peaks in 2008 but firm specific uncertainty peaks in 2002. One possible reason is that we controlled year dummies when we estimate . Another difference is that SD1 has a lagged respond to policy uncertainty. From the figure, we can find that the two peaks of policy uncertainty are in 2001 and 2008, but SD1 peaks in 2002 and 2009. This is also reasonable because firms need some time to respond to policy uncertainty.

tributed as N(0,1) under the null of no serial correlation. Hansen test is distributed as Chi-square under the null of instrument validity.

[28]Please see more description in http://www.policyuncertainty.com/china_monthly.html.

Figure 5.A.2: Average cash holdings from 2000 to 2010



If we compare the uncertainty with average cash holdings from 2000-2010 (The values are listed in Table 5.4). We can also find some consistency between cash holdings and uncertainty.

5.B Value function iteration

The equation (5.10) is the Bellman equation needs to be solved is:

$$U(k, c, z) = \max\left\{u(k, k', c, c', z) + \beta E_{z'|z} U(k', c', z')\right\}$$

The function has no analytical solutions but we can write the first order condition as:

$$\frac{\partial U(k,c,z)}{\partial k'} = \frac{\partial u(k,k',c,c',z)}{\partial k'} + \beta E_{z'|z} \frac{\partial U(k',c',z')}{\partial k'} = 0 \tag{a1}$$

Although we do not know $\frac{\partial U(k',c',z')}{\partial k'}$, we can get:

$$\frac{\partial U(k,c,z)}{\partial k} = \frac{\partial u(k,k',c,c',z)}{\partial k} \tag{a2}$$

Assume:

$$\frac{\partial U(k,c,z)}{\partial k} = \frac{\partial U(k',c',z')}{\partial k'}$$

Substitute Equation (a2) into Equation (a1), and we will have:

$$\frac{\partial u(k,k',c,c',z)}{\partial k'} + \beta E_{z'|z} \frac{\partial u(k,k',c,c',z)}{\partial k} = 0 \tag{a3}$$

With the same method we can also get:

$$\frac{\partial u(k,k',c,c',z)}{\partial c'} + \beta E_{z'|z} \frac{\partial u(k,k',c,c',z)}{\partial c} = 0 \tag{a4}$$

The algorithm of value function iteration:

- Discretizing the state variables z, k, c into 25, 25 and 15 grid points respectively.
- Start with a guess for the true value function $v1$.(We guess initial $v1$ to be 0). Use it on the Bellman equation, and we could get $v2$.
- Update $v1 = v2$ and put $v1$ on Bellman equation again. We keep this process running until $v1$ converges to a fixed value. With the converged value we could find out the optimal choice of investment.

5.C Simulated method of moments estimation

We estimate the parameters regarding confidence shocks using SMM. We set risk-free interest rate r equal to 0.032; quadratic adjustment cost g=0.4. Idiosyncratic shock σ=0.3; output elasticity of capital gamma=0.75, and finally, external financing cost, λ=0.08. We want to estimate parameters: a, the parameter measures ambiguity aversion; b the target. In our paper, we suggests that firms use cash to hedge negative income shocks, so cash holdings target on cash flow/EBIT/Operating Revenue; and ρ, the persistence of the shock.

Table 5.C.1: Empirical moments

	full sample	2007-2010
$mean(I_t)$	0.118	0.117
$mean(C_t)$	0.367	0.397
$corr(I_t, C_t)$	-0.0783	-0.127
$corr(C_t, C_{t-1})$	0.822	0.852

Table 5.C.2: Parameter estimation

	full sample	2007-2010
Parameters		
a	0.9714	1.2816
	(0.1475)	(0.234)
ρ	0.7983	0.8402
	(0.0007)	(0.0017)
b	8.9478	9.85
	(0.0019)	(0.0017)
Simulated Moments		
$mean(I_t)$	0.0935	0.0888
$mean(C_t)$	0.3491	0.3789
$corr(I_t, C_t)$	-0.0834	-0.1641
$corr(C_t, C_{t-1})$	0.8236	0.8342
Fitness	537.566	229.784

Table 5.C.1 reports the moments of our empirical data. The moments we select are $mean(I_t)$, $mean(C_t)$, $corr(I_t, C_t)$, $corr(C_t, C_{t-1})$. Here we define I_t as $investment/k+c$,

investment over tangible fixed assets and cash. C_t is defined as cash over tangible fixed assets and cash. The reason is because we find that in China, intangible assets are too large, so the fixed asset investment rate is very low. We find an extremely high cash holding rate. Negative and low correlation between investment and cash holdings. High serial correlation of cash holdings. We estimate the parameters with a full sample, China listed firms from 1998 to 2010 and sub-sample from 2007 to 2010 after the financial crisis.

We match the moments with structural parameters (Table 5.C.2), and we find that a=0.97, b=8.9 and ρ=0.79 for the full sample. After the crisis, a increases to 1.28, which shows that firms are more averse to ambiguity and the target level of cash increases to 9.85 as well. In addition we find a higher serial correlation of productivity ρ, which increase to 0.84. The serial correlation is higher that Nikolov and Whited (2014) (between 0.61-0.71), but lower than 0.885 in Cooper and Haltiwanger (2006). So the result is reasonable.

The high ambiguity aversion level suggests that the type 2 precautionary savings is very important. Type 2 precautionary savings is also the key of positive cash-cash flow sensitivity.

5.D Additional data description and summary statistics

Table 5.D.1: Cash holdings and uncertainty

VARIABLES	mean	sd	p25	p50	p75
$\Delta Cash_{i,t}/MV_{i,t-1}$	0.0162	0.0962	-0.0199	0.00519	0.0385
$\Delta E_{i,t}/MV_{i,t-1}$	0.0417	0.0751	0.0202	0.0407	0.0676
$\Delta NA_{i,t}/MV_{i,t-1}$	0.0296	0.121	-0.00957	0.00574	0.0421
$\Delta D_{i,t}/MV_{i,t-1}$	0.00192	0.0175	-0.00365	0.000820	0.00664
$Cash_{i,t}/MV_{i,t-1}$	0.127	0.118	0.0557	0.101	0.168

Notes: ΔX indicates a change in X from year $t-1$ to t. $r_{i,t}$ =Annual Return with Cash Dividend Reinvested, R_t^M =Annual Market Return with Cash Dividend Reinvested, $MV_{i,t}$ =Market Value of Equity +Market Value of Net debt, $E_{i,t}$=Earnings before Extraordinary (EBIT) between time $t-1$ and t, $NA_{i,t}$=Net Tangible Asset at time t, $D_{i,t}$ =Cash Paid For Distribution Of Dividends Or Profits Or Cash Paid For Interest Expenses

5.E Additional estimation results

Table 5.E.1: Cash holdings and uncertainty

	(1)	(2)	(3)	(4)
q	0.00244	0.00240	0.00206	0.00207
	(0.00161)	(0.00161)	(0.00167)	(0.00167)
$Cashflow/A$	0.351***	0.317***	0.348***	0.318***
	(0.0111)	(0.0137)	(0.0115)	(0.0139)
SD1	0.00990**	0.00525		
	(0.00391)	(0.00406)		
$Cashflow/A$*SD1		0.103***		
		(0.0246)		
SD2			0.00515	0.000760
			(0.00351)	(0.00369)
$Cashflow/A$*SD2				0.105***
				(0.0270)
size	0.0310***	0.0307***	0.0319***	0.0316***
	(0.00227)	(0.00227)	(0.00236)	(0.00235)
Observations	10,363	10,363	9,874	9,874
R-squared	0.168	0.170	0.166	0.168

Notes: q is Tobin's q. $Cashflow/A$ is the ratio of cash flow to total assets. SD1 and SD2 are proxies of uncertainty. The regressions are estimated with fixed effect method.

Table 5.E.2: Cash holdings and uncertainty

VARIABLES	(1)	(2)
$\Delta Cash/MV_{i,t-1}$	1.247***	1.286***
	(0.331)	(0.317)
$\Delta E/MV_{i,t-1}$	2.120***	2.182***
	(0.203)	(0.212)
$\Delta NA/MV_{i,t-1}$	-0.117	-0.168**
	(0.0945)	(0.0787)
$\Delta D/MV_{i,t-1}$	-1.031*	-0.976*
	(0.564)	(0.570)
$Cash/MV_{i,t-1}$	0.150*	0.162*
	(0.0847)	(0.0863)
$Cash_{i,t-1}/MV_{i,t-1} * \Delta Cash/MV_{i,t-1}$	0.990	0.837
	(1.491)	(1.437)
$Leverage * \Delta Cash/MV_{i,t-1}$	-0.691	-0.727
	(0.772)	(0.802)
$leverage$	0.0809**	0.114**
	(0.0407)	(0.0449)
$SD1 * \Delta Cash/MV_{i,t-1}$	-0.724***	
	(0.197)	
$SD2 * \Delta Cash/MV_{i,t-1}$		-0.589***
		(0.155)
$NF/MV_{i,t-1}$	-0.0845	-0.121
	(0.111)	(0.106)
Observations	10,154	9,679
R-squared	0.099	0.103

Notes: To be consistent with Faulkender and Wang (2006), and Dittmar and Mahrt-Smith (2007), the regressions are estimated with OLS.

5.F Variable definitions

Tobin's q: ratio of market value over ending total assets

Sales: the cash actually received by an enterprise for the goods sold and services rendered, including cash received in the current period for the goods sold (products and materials) and services rendered in the current period, cash received in the current period for goods sold and services rendered in the previous periods, as well as cash advances received in the current period, less cash refunded in the current period for goods sold and returned in the current period or for goods sold in previous periods but returned in the current period.

Sales growth (Δy): the difference between the logarithm of total sales of end of year t and end of year $t-1$

Cash: the company total of cash on hand, bank deposits, overseas deposits, bank draft deposits, cashier's cheque deposits, credit card deposits, L/C deposits, etc.

Leverage: the ratio of the sum long-term debts and short-term borrowings to total assets

CAPEX: cash paid to acquire and construct fixed assets; intangible assets and other long-term assets

CAPSALE: cash received from disposal of fixed assets; intangible assets and other long-term assets

Size: the sum of the firm's fixed and current assets, where fixed assets include tangible fixed assets, intangible fixed assets, and other fixed assets; and current assets include inventories, accounts receivable, and other current assets.

Cash flow: operating cash flow , net cash flow from operating activities

$r_{i,t}$: annual return with cash dividend reinvested

R_t^M: annual market return with cash dividend reinvested

$E_{i,t}$: EBIT, total profit plus financial expenses

$NA_{I,t}$: net tangible asset, book value of tangible fixed assets (which include land and building; fixtures and fittings; and plant and vehicles)

$NF_{I,t}$: net financing cash flow

D_{it}: cash paid for distribution of dividends or profits or cash paid for interest expenses

$SD1_{it}$: 3-year moving standard deviation of the unpredictable part of operating income, which is the income of sales of goods and services

$SD2_{it}$: 2-year moving standard deviation of the unpredictable part of operating income, which is the income of salesof goods and services

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Chapter 6

Conclusion

In conclusion, the thesis is comprised of four main chapters. In this section we will summarize the theoretical and empirical findings of our thesis. We will also provide several policy implications. Finally, we propose several directions for future research.

6.1 Summary of key results

After an introduction of the thesis, Chapter 2 starts with a review of the empirical and theoretical literature of corporate finance. It is very interesting to find that theoretical and empirical findings sometimes are hard to reconcile. Even empirical findings themselves are contrary to each other. From the beginning of corporate finance debate starts from a simple assumption, that firm's only goal is to maximise shareholder's value. However, the real world is much more complicated than this. We find that firms need to handle a lot of problems, such as financing constraints, adjustment costs, uncertainty, risk management and agency problems etc.

Then there are many equilibria to achieve. When firms are financially constrained, managers need to balance the profit and cost of external finance. When firms want to change capital structure, managers need to balance the benefits which can be obtained from buying or selling some assets and the costs of doing so. When managers are very uncertain about the future, they need to think about the likelihood of loss, default or bankruptcy and balance profit and risk.

Managers need to balance long term interests with short term interests. So, they may want maximise long term value rather than short term. Meanwhile, managers may also be aware that in the long run uncertainty may be very large. Of course it is undeniable that principle and agency interests are different. Managers also need to balance their own interests with shareholders' interests.

The dynamic equilibrium lead firms to make different decisions and these decisions are far from their initial goal. That is why it is very hard to explain some results and why some empirical results are changing under different conditions.

We then review the corporate finance literature of China. In the context of China, there are some specific issues which need to be addressed. First, financial system in China is less developed. Second, the private sector is not given as much resource as the state sector. Finally, there are also some institutional problems. So, when we focus on China specific issues, we can always find some puzzles that cannot be explained with conventional ideas.

For example, why do private firms in China grow so fast given severe financing constraints? In Chapter 3, we try to answer this question from the perspective of investment sensitivity to investment opportunities. We decomposed q model and measure q from both demand side and supply side. We find that private firms are very sensitive to investment opportunities from both supply side and demand side. SOEs are less sensitive to investment opportunities, especially from the demand side. Firms owned by foreign investors on the other hand are very sensitive to demand shocks. The results suggest that private firms are very sensitive to investment opportunities which can explain their rapid growth.

Chapter 4 suggested a new channel to explain why investment-cash flow sensitivity is high in China despite cash flow being far higher than investment. We use sales growth as the proxy of investment opportunity. We find that uncertainty plays an important role to explain investment cash flow sensitivities. There are several interesting findings. First we find that investment is positively related to sales growth. However, the sensitivity of investment to sales growth is lower when sales growth is high. Then we take uncertainty into consideration. Second, we find that uncertainty has a negatively impact on investment. In addition, we find that uncertainty can explain the concave relationship between investment and sales growth. Thirdly, we find that uncertainty can increase the investment-cash flow sensitivity of private firms. Uncertainty can decrease the investment sensitivity to investment opportunities.

The results indicate that firm's investment is more sensitive to investment opportunities when uncertainty is low, while more sensitive to cash flow when uncertainty is high.

In Chapter 5, we developed a model on corporate savings. We take financing constraints, uncertainty, adjustment costs and confidence shocks into consideration. We find two types of precautionary savings. Type 1 precautionary savings is defined as firms which save cash in bad times to use in good times. The motivation of type 1 precautionary savings is to tackle the likelihood of financing constraints if they want to invest a big project. Type 2 precautionary savings is that firms save cash in good times and use in bad times to hedge the shortfall of income.

We empirically tested our data on Chinese listed firms. We find that the cash-cash flow sensitivity is positive in China. This result supports our type 2 precautionary saving hypothesis. We find a positive relationship between cash holdings and uncertainty. Moreover, uncertainty can also increase cash-cash flow sensitivity.

Then we find that uncertainty can increase firms' cash holdings, but marginal market value of cash holdings will decrease if uncertainty increases. This suggests that high uncertainty leads firms to save more excess cash. We also estimate the sample after the financial crisis (2008-2010). The results suggest that given the same level of uncertainty, during the financial crisis uncertainty will decrease marginal market cash value more. In other words, firms will hold more excess cash because of uncertainty. The results suggest that firm's cash holding decisions are not only affected by uncertainty shocks but also confidence shocks.

We report structural estimation parameters in our appendix. The results suggest that firms are less confident after the financial crisis and they will target their cash holdings to a higher level. However, there are some limitations of using this method. First, the parameters calibrated are used from US literature. In China some parameters may be different. However, we cannot find other papers which study this issue using Chinese data before us. Second, for listed firms in China, the value of tangible fixed assets is too low but total asset value is too high. This will make it hard to choose which type of assets to use when we calculate variables such as investment to capital ratio, cash to capital ratio.

Our findings suggest several important policy implications: the findings of Chapter 3 suggest that policymakers can use difference policies to stimulate firm's fixed capital investment with different ownerships. In Chapter 4, we suggest that when uncertainty is high, firms need more cash flow. Implementing some monetary policies maybe more helpful than stimulating fundamental. Finally, in Chapter 5, we suggest that if policymakers want to encourage firms to hold less cash, they could decrease uncertainty, and release some signals to strengthen manager's confidence. Meanwhile, more financial instruments are needed to hedge uncertainty.

6.2 Proposal for future research

This thesis suggests further research in corporate finance. There are several interesting topics.

6.2.1 Extension in financial constraints

Empirically, we can further examine the effect of financial constraints. As we found in our thesis, Chinese firms have very high cash flows. Are they truly financially constrained? There are many papers which introduced financial constrained as a consequence and regard financing constraints as frictions. However, in chapter 3, we find that financially constrained firms grow faster than unconstrained firms. More research could be developed on this finding. Since external finance is very expensive for financing constrained firms, they are not likely to invest in projects with low profitability. So, we can test whether or not financial constraint can help firms to increase investment efficiency.

Theoretically more research can be developed to find the mechanisms of financing constraint. People measure financing constraints with some probabilities. For example, it is very common to find that many papers use size as a classification criteria for financing constraints, and they call small firms as the firms most likely to face financing constraints. However, it is very unclear what causes financing constraints. There are two possible explanations. First, the external financing cost is too high. Second, they have no access to external funds. Theoretically, these two mechanisms can generate different results and can be used to tackle different problems.

6.2.2 Extension in uncertainty and cash holdings

Empirically, the definitions of uncertainty are varied, there are also many different types of uncertainties. We can measure different types of uncertainty and check how different firms respond to different types of uncertainty.

In our paper, we find that firms hold cash to hedge income shortfalls in bad times. This can explain the positive relationship between cash and cash flow. However, in terms of the level of cash, we find that firms accumulate far more cash than income short falls. There should be other purposes for firms to hold so much cash. It would be very interesting to find out why they accumulate so much more cash than they actually need.