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Essays in Corporate Finance: Empirical Applications in China

by

Zerun Liu

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Abstract

China has experienced rapid economic growth in the latest 40 years. From the macro perspective, the economic boom could be owing to the increase in the fixed investment, international trade and the input in innovation activities. However, in the micro level, it is interesting that how the Chinese firms grow so rapidly in the imperfect market with financing constraints. Therefore, this thesis focuses firm's real decisions in export, fixed investment and innovation activities. The contributed chapters are structured as follows.

The research topic of the chapter 3 is whether working capital investment helps the firm's export decision. We employ panel a containing around 37,000 non-listed firms with different ownership types from 2000 to 2007. The main finding is that exporters can rely on working capital investment to promote their export probability. The group of continuous firms (including successful and new exporters) shows a stronger effect of working capital investment on export than that in the switch exporters group. Firms with private ownership most rely on working capital investment in the export while the state-owned enterprises (SOEs) may not rely on the working capital during the export. In addition, only firms with relatively high level of working capital can use it to promote export.

In the chapter 4, we use the stochastic frontier approach (SFA) to estimate firm's level of the investment cash flow sensitivity (ICFS). By using a panel of 66500 Chinese unlisted firms between 2000 and 2007, we find the higher level of cash flows and better financial conditions can alleviate financial constraints. In the post estimation analysis, we find that the investment efficiency distribution is roughly right-skewed, and the private firms show the highest efficiency while the SOE firms show the lowest. Firms in the regions with higher level of legal institution show higher efficiency. Industries in the tertiary sector show a relative higher efficiency than industries in the secondary sector, but some industries in the tertiary sector display a different tendency of financial constraint, which may be affected by the firm ownership.

The chapter 5 investigates how firms use the cash flow to smooth the research and development (R&D) projects. By using a panel from Chinese firms listed in the A-share exchanges, we find that the cash holding plays a smoothing role in the R&D investment in the presence of the temporary economic shock or short-term cash flow fluctuation. Firms with R&D use both the external and internal finance to support the R&D project. Larger

firms are likely to invest more in R&D. The innovation investments in SoE firms are not significant in the changes of cash holding. A higher level of cash flow will weaken the R&D investment smoothing mechanism. Firms with high level of productivity are more sensitive to the changes in cash holding than their lower productivity counterparts. Firms with high level of ownership concentration are less sensitive to the changes in cash holding than their low level concentrated counterparts.

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Author’s 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.”

Printed Name: Zerun Liu

Signature:

Chapter 1 - Introduction

From the year 1978, China has proposed a “reform and opening up” policy. After 40 years of economic reform, China’s aggregate output increased from 150 billion US dollars in 1978 to 12.24 trillion in 2017. The average GDP growth rate has been around 9.5% in the last 40 years. During this period, China has gone through an investment boom. The average Gross fixed capital formation has been 32% of GDP since 1978 and was 36% between 2007 and 2017 (World Development Indicators, 2018).

However, for China’s economy, fixed investment growth has not been the only engine for the boom in the past decades. Another important parameter is international trade. The amount of net trade in goods and services surged from 4.17 billion US dollars in 1982 to 357.9 billion in 2015. International trade has averaged 36% of GDP since 1982 and peaked at 64% in 2006 (World Development Indicators, 2018).

In addition, according to the endogenous growth theory (Romer, 1990; Aghion and Howitt, 1992), the key driver of economic growth is research and innovation. According to OECD (2018), gross domestic spending on R&D in China increased consistently from 0.893% in 2000 to 2.108% in 2016. If we consider that the average growth rate of China's GDP is around 7% from 2000 onwards, the level of innovation growth should be even more striking. Therefore, in order to understand China’s economic growth in the past decades, investment, international trade and the innovation should be all taken into account.

The discussion above is at the macro level. With respect to the micro level, we need to note that the capital markets have many frictions since the capital markets are not perfect. Hence, for firms, the cells of the aggregate economy, financial constraints would be a crucial problem. The definition of a financial constraint is that firms cannot access funds to invest at the optimal level. Therefore, the growth rate of firms with liquidity constraints would be inhibited. Fazzari et al. (1988) is the first article to empirically support the view that, if firms are in constraint, there are positive connections between the firms’ fixed investment and the cash flow. To be more specific, when firms cannot access external funds, they have to invest the projects by internal finance (e.g. cash flow). Subsequent studies based on Fazzari et al. (1988) have also found that financial constraints may impact on the firm’s inventory (Carpenter et al., 1994), employment (Nickell & Nicolitsas, 1999), research and development (Hall, 1992; Mulkay et al., 2000).

In terms of Chinese firms, it is worthwhile to study the relationship between the financial constraints and a firm's real decisions. There are three reasons to use Chinese firms as the sample to make experiments. Firstly, Chinese firms can be divided into two kinds: the state-owned enterprises (SOEs) and the non-state-owned enterprises (non-SOEs). The SOEs are highly likely to receive intervened by the government, and they may be benefit from the "soft budget constraint" (Allen et al., 2005; Chen et al., 2011). Secondly, in the past decades, although the private economy and the legal environment have been remarkably improved, firms with private ownership still face financial constraints (Lardy, 2014). Therefore, firms in the private sector have to protect themselves against liquidity constraint in order to survive and grow. Thirdly, studying the situation at the level of the firm can help us better understanding the miracle aggregate growth in the past decades.

Therefore, reviewing the discussion so far, it is meaningful to study the Chinese firms in terms of the parameters supporting the economic growth. We firstly pay attention to the financial constraints and the international trade. In terms of alleviating the financial constraints, Fazzari and Peterson (1993) conduct an investigation of US firms and find that these firms can effectively use their working capital to smooth out their cash flow fluctuations. Other than adjusting the working capital as a whole, the adjustment of components of working capital is also an eligible solution for firms to relieve their liquidity constraint. Carpenter et al. (1994) also employ US firm data and find that the disinvestment of inventory has positive effect in accumulating the cash flow. For Chinese firms, Ding et al. (2013) employ a similar method to that of Fazzari and Petersen (1993) and find that Chinese manufacturing firms with relatively higher level of working capital may choose to use working capital to allow for alleviation in the presence of cash flow shocks.

However, regarding the studies regarding financial constraint and export activity, we found that the research is mainly focused on the cross-country or country level. For instance, Manova (2008) finds that financial market liberalization is usually associated with greater exports, especially for the financial vulnerable sectors. For the export firms, apart from their financial constraints, there is another crucial factor which may impede a firm in the export market: sunk cost. Melitz (2003) further finds that only the high productivity firms, or firms that can afford to cover the sunk cost, could enter into the export market. Das et al. (2007) also find that the small firms will be more affected by the sunk cost.

Hence, it is worth studying how Chinese firms can overcome the sunk cost when they are facing the liquidity constraints. The majority of Chinese manufacturing firms may face liquidity constraint when they want to be exporters, and they may use working capital investment to alleviate this. Therefore, our main research question is: for Chinese firms, can working capital investment help the firm export? We managed to answer this question in Chapter 3. In that chapter, we construct a binary probit model to investigate the relationship between working capital sensitivity and export decision at firm level. Empirically, we divide the firms into several groups by export status (successful, new, switch and exit exporters) and ownership (SOE, private, foreign and collective) and estimate the probit model by maximum likelihood method.

The data is from the annual survey conducted by the National Bureau of Statistics (NBS) of China. The panel we used contains around 37,000 non-listed firms and more than 270,000 observations from 2000 to 2007. The findings can be concluded as follows. Firstly, new exporters is the group which most rely on working capital investment to promote their export probability. The group of continuous firms (including successful and new exporters) shows a stronger effect of working capital investment on export than that in the switch exporters group. The exit group does not show such an effect since their level of working capital investment is relatively low. In terms of different ownership groups, the SOEs are not sensitive to working capital investment. For the other groups, the private group most relies on working capital investment whilst the foreign group least relies on that. In addition, we also find that only firms with relatively high level of working capital can use it to promote export since the marginal adjustment cost is low.

The main contribution of this chapter is to provide a channel showing that financially constrained firms can overcome the sunk cost during export by using a source of internal funds.

Secondly, we focus on the relationship between the financial constraints and the fixed investments. There are a large number of research articles in this area (see Guariglia, 2008, as a survey), and extensive methods are provided to determine the financial constraints. However, these methods have some common drawbacks. First, methods in the stylized literature only provide marginal effect, but fail to provide a firm-specific and time-varying variable to direct measure the financial constraint. Second, some methods need to make *a priori* classification of samples, which may cause sample selection biases.

Therefore, in chapter 4, following Wang (2003) and Bhaumik et al. (2012), we use the stochastic frontier approach (SFA) to overcome some of the abovementioned problems. The SFA does not separate samples *a priori* to test investment cash flow sensitivity (ICFS). In addition, this method can provide not only cross-sectional, but also intertemporal comparisons of the financial constraint effects. In this chapter, we not only examine the ICFS, which is similar to the stylized literature, but also test the investment efficiency among different firm characteristics.

The data source is from a panel of 66500 Chinese unlisted firms, for the period of 2000-2007. We identify firm characteristics that explain variations in these measures across firms and over time. Our main findings are that, in accordance with the existing literature in firm-level investments, higher level of cash flows, assets and coverage ratio can alleviate financial constraints. The degree of financial constraint is higher for highly leveraged firms. We also make post estimations to determine whether ownership, region and industry type affect the firms' financial constraint status. For the entire samples, the investment efficiency distribution is roughly right-skewed, indicating that the majority of firms show a significant level of financial constraint, and that the private firms show the highest efficiency while the SOE firms show the lowest efficiency. However, the foreign firms show a lower efficiency than the private and collective counterparts. Firms in the regions with superior level of legal institution show higher efficiency. In addition, we find that industries in the tertiary sector show a relative higher efficiency than industries in the secondary sector. However the secondary sectors show a more stable efficiency across years. Finally, some industries in the tertiary sector display a different tendency of financial constraint, which may be affected by the firm ownership.

The contributions are twofold. Firstly, rather than inferring the existence of financial constraint from the sign and significance of the cash flow variable, the SFA method enables us to estimate a measure of financial constraint for each individual firm and at each point in time. Secondly, we are able to directly estimate the marginal impact of firm characteristics such as size, leverage and coverage on financial constraint, without inferring the different degrees of financial constraint on different types of firms, by splitting the sample into different groups based on of any *ad hoc* criteria; thereafter we estimate the different degrees of responsiveness of the investment of the average firm in each of these groups to cash flows.

Thirdly, we move to the relationship between the financial constraint and the innovation activities. As discussed at the beginning of this chapter, the R&D expenditure ratio was enhanced from 0.3% in 2007 to 2.2% in 2016. Therefore, there is a question: how do the Chinese firms keep consistent innovation outlay? This is an interesting question for the Chinese firms, since they are confronted with external pressures such as the financial crisis. In addition, the nature of R&D investment is long period, hardly reversible, and limited collateral value (Brown and Peterson, 2011). Hence, the R&D projects are highly likely to be hampered by an asymmetric information problem, which means the firms may not access external funds for their innovation investments.

In the meantime, we note that firms' cash holding level is increasing in recent years, both for the firms in developed economics and in China. For Chinese firms, the average level of cash holding in the A-shares market increased from 17.1% in 2007 to 21.3% in 2016. However, holding cash has a high level of opportunity cost. For instance, managers could invest cash in investments with suboptimal efficiency to obtain personal benefits, while at the same time decreasing shareholders' wealth (Jensen & Meckling, 1976). Therefore, another question occurs: why do firms hoard so much cash in spite of the opportunity costs?

In chapter 5, we connected the two questions above. One possible explanation is that cash holding may help firms invest in the R&D project persistently. To be more specific, in the presence of temporarily shocks, firms can use their cash holdings to smooth the R&D expenditure. Following Brown et al. (2009) and Brown and Peterson (2011), we employ a reduced Euler equation model to investigate the relationship between the R&D investment and cash holding. In the meantime, we also consider the factors of source of funds, a firm's productivity and ownership concertation. The estimation method is system GMM.

The data is obtained from the China Stock Market Trading Database (CSMAR), including 23,122 observations from 3,175 firms between the years 2007 and 2016. The findings are concluded as below. First, we find that the R&D investment is persistent, while its adjustment cost is a convex function. The change of cash holdings is negatively related to the R&D investment. This implies that the cash holding plays a smoothing role in the R&D investment in the presence of the temporary economic shock or short-term cash flow fluctuation. Firms with R&D use both the external and internal finance to support the R&D project. Larger firms are likely to invest more in R&D. SoE firms are not significant in the changes of cash holding, meaning that they may not be relying on the smoothing channel during the innovation project. In the augmented model estimation, we find that a higher level of cash flow will weaken the R&D investment smoothing mechanism. Both high and low productive firms use the smoothing channel during the R&D investment. However, firms with high level of productivity are more sensitive to the changes in cash holding than their lower productivity counterparts. For the ownership structure, firms with lower level of the ownership concertation are more sensitive to Δcashholding than those firms in higher ownership concentration.

Chapter 2 - Background section: China's financial system and SOE firms

In this chapter, we will make a brief introduction about the financial system and SOE firms in China. The financial system in China is dominated by larger state-owned banks, which may impede the small and medium enterprises from accessing the external finance. Therefore, we will provide a sketch of the evolution in the banking sector. In addition, we will introduce briefly the stock and bond market. With respect to the SOE firms, it is meaningful to provide an overview and focus on performance, as well as on the reform. This is because, in the following empirical chapters, the results from the SOE firms are vastly different from those for the non-SOE firms. Therefore, we believe that introducing the background of the financial system and SOE firms could help better understanding of the following empirical chapters.

2.1 China's Banking based financial system

China's financial system is now a participant in the global financial system. However, the structure of the system is different to that of other large Asian economies such as Japan and India. We should note that the Chinese financial industry is still dominated by bank lending (Tsai, 2015). In the year of 2017, the amount of banking credit was 155.82% of the GDP, while the size of the capital market (i.e. bond and stock markets) is 71.2% of the GDP. In the meantime, the size of banking credit in US and UK are 52.8% and 76.9%, respectively. The amount of the capital market of the GDP are 164.8% and 130.35% (World Bank, 2019). Compared with these two developed economics, China has a bank-based financial system, while those in the US and the UK are market-based. In the major developed economies, Germany has a bank-based financial system. According to World Bank (2019), its size of banking credit of GDP is 135.1%, and the capital market size is 65.1% of the GDP in 2017. Therefore, it is meaningful to introduce the China's banking sector separately. In this part, we will briefly introduce its evolution since 1978. For the stock and bond market, we will briefly discuss their establishment and development.

2.1.1 Evolution of the commercial banking

The first stage of the banking system revolution occurred between 1978 and 1992. In this stage, the main aim was to change the original mono-banking system into a system consisting of a central bank and various kinds of financial institutions. The reform started from the 3rd Plenum of the 11th central committee of the CPC, which put forward the "reform and opening" policy. During the period 1978-85, the central government focused on abolishing the mono-banking system. From year 1986, some new banks were established. The People's Bank of China (PBC) was the only bank in China until 1979. In 1984, the PBC was defined as China's central bank. However, rather than being independent of the government, it was part of the State Council (the Cabinet). In order to diversify the banking sector, new banks were established. For instance, the four large state-owned banks, namely the Agricultural Bank of China (ABC), the Bank of China (BOC), the People's Construction Bank of China (renamed China Construction Bank, CCB, in 1996), and the Industrial and Commercial Bank of China (ICBC), were either re-established or were separated from the PBC or China's Ministry of Finance. These new banks had several types of shareholders, including local government organizations and state-owned enterprises (SOEs), they became known as joint stock commercial banks (JSCBs).

The starting point of the second stage of the banking system reform can be regarded as the time after the 14th National Congress of the CPC formally initiated the "socialist market economy" concept. After that, between 1993 and 1997, the government had dealt with several crucial issues, as discussed below. First of all, the central government separated the policy lending services from the SOE banks. Therefore, the China Development Bank (CDB), the China Import and Export Bank (CIEB), and the Agricultural Development Bank of China (ADBC), which are defined as the only three policy banks, were established to take over policy lending (Lin and Zhang, 2009). Since then, the four banks have been called state-owned commercial banks (SOCBs). Moreover, the CPC started implementation of the financial laws and regulations. For example, a central bank law and a commercial bank law were enforced in 1995. In addition, the government tried to improve the basic environment for its financial markets. It established the China Foreign Exchange Trading System and the National Interbank Funding Center to unify the foreign exchange rates and interbank market rates, respectively, which, until then, had shown different rates in the local trading centers. The government also began promoting the development of a nationwide electronic payment and settlement system to enable financial institutions to move funds more flexibly. The outbreak of Asian financial crisis in 1997 had made the government reinforce the regulations of the financial institutions. In 1998, the authority launched a bank bailout amounting to 3.1% of GDP to save the SOCBs. In addition, four state-owned asset management companies (AMCs) had been established to absorb almost RMB 1.4 trillion in bad loans between 2000 and 2001.

The third stage began at the year of 2001, when China accessed the World Trade Organization (WTO). In order to comply with the requirements of the entrance of WTO, in 2002, the government decided to proceed to further reform and openness in the financial industries. The four SOCBs were the main target to clear and restructure their ownership systems. Therefore, the government decided to implement a more market-oriented strategy to resolve the banks' problems. The detailed targets for the reform were to change the SOCBs to listed commercial banks, and to improve their corporate governance and management efficiency. This was followed by the international listing of three of the four large SOCBs between 2005 and 2006. The Agricultural Bank of China, which is the fourth SOCB, was listed in 2010. For the JSCBs, the government also encouraged them to restructure their balance sheets and to list their shares on stock exchanges. By the end of 2017, 39 banks were listed on the stock markets, usually in Shanghai and Hong Kong. The benefit of being listed firms for the SOCBs and JSCBs is evident: these banks can structure themselves along these lines of modern corporations, and improve the quality of their corporate governance. Therefore, being listed helped these banks to catch up with their international counterparts (Sun and Tobin, 2005). In the meantime, one of the new trials of the reform in this stage was the introduction of foreign strategic investors. From December 2003, foreign strategic investors were allowed to inject funds into Chinese banks directly as minority investors, to increase the banks' credibility with regard to global IPOs and to help them to improve their corporate governance and risk management systems. By the end of 2014, 42 Chinese listed and non-listed banks had, between them, introduced 50 foreign institutional investors as partners with minority ownership shares with the largest share being 20 percent (Cheng et al., 2016). In terms of the disposal of the non-performing loans (NPLs), by July 2010, the SOCBs had disposed of NPLs totaling about RMB 2 trillion. In addition, the government had tried to rebuild small and medium local financial institutions. City commercial banks were established by merging more than 5,000 city credit cooperatives. By the end of 2015, there were 133 city commercial banks, most of which included investment by local governments. However, the market shares of the foreign banks were still in low presence. By the end of 2010, the percentage of the market share for foreign banks was only at 1.8%. This feature contrasts sharply with the experience from other transitional economies. Bonin et al. (2010) found that the market share of foreign banking accounted for more than 50% after a decade of reform in Hungary and Poland.

The origin of the fourth stage can be regarded as the year 2012. In this year, the then Premier Wen Jiabao initiated breaking up the monopoly of the state-owned banking system. Following this purpose, the lending rate floor was removed in 2013. In the same year, the PBC introduced a standing lending facility to meet large scale demand for long term liquidity and Short-Term Liquidity Operations to facilitate repurchase operations with shorter term maturities (Sun, 2015). This reform was designed to give banks greater flexibility in the pricing of risk, but to limit competition by retaining control over deposit rates (Tobin & Volz, 2018). In 2014, the China Banking Regulatory Commission (CBRC) relaxed its stance on the components used to calculate banks' loan to deposit ratios, which could effectively allow banks to expand liquidity (Okazaki, 2017). From the customer perspective, a deposit insurance scheme was implemented. This was to protect the customers against bank collapse. In addition, in October 2015, it was announced that the deposit rate cap, which was previously fixed by the PBC, would be lifted. This move allowed deposit-taking institutions to compete for deposit funds.

2.1.2 Stock markets

The emergence of Shanghai and Shenzhen as China's major financial centers can be traced to the establishment in 1990 of stock exchanges in both cities. Both municipal governments, who oversaw the development of stock markets until the late 1990s, followed policies based on equity developmentalism. Recently both cities have been approved to pilot Free Trade Zones (FTZs) and Stock Connect schemes. The FTZs were designed to allow controlled off-shore goods and currency trading for domestic traders or banks and their international counterparts. Shanghai's FTZ was launched in 2013 while Shenzhen's was launched in 2015. The Stock Connect schemes allowed approved overseas investors to purchase domestic shares via Hong Kong, China's off-shore financial market. Shanghai was the first to benefit from this in 2014 and the scheme was extended to Shenzhen in 2016. The developments have seen Shanghai and Shenzhen emerge as the world's 6th and 20th largest financial centers respectively by 2017 (Yeandle, 2017).

The development of the stock market was very fast. For the number of listed companies, the number has increased from 10 in year 1990 to 3,485 in year 2017 (World Bank, 2018). However, there are still some unresolved challenges. Firstly, as we discussed above, compared with the banking sectors, the size of the stock market is small. Secondly, the trading patterns are highly erratic. For instance, the average turnover ratio on the Shanghai exchange market was 388% in 2015, while the market had a price earnings ratio of 17.6%. These figures imply that the increase in market activity was driven by a small but relatively wealthy group of shareholders who only had comparatively small portions of total shares. Thirdly, compared with the overseas stock exchanges and financial markets, the financial products provided by the Shanghai and Shenzhen exchanges are relatively monotonic. However, offering more sophisticated range of financial products is constrained by the lack of a fully convertible RMB and capital controls imposed by the government.

2.1.3 Bond markets

In China, the government and corporate bonds are traded on the Shanghai and Shenzhen stock exchanges, over the counter (OTC) and in the inter-bank bond market. The inter-bank market is the most crucial market for the bond trading. In the recent years, bonds have become a major component of wealth management products (WMPs). For example, the banks usually hire securities companies to manage the proceeds of WMPs. In the meantime, the securities companies would use repurchase agreements to hold out the bond prices (BIS, 2017). Capital account controls and a limited pool of off-shore RMB liquidity have meant relatively few international issues of Chinese government bonds.

Much of the early growth of the China's bond markets was motivated by the demands that financing economic growth placed on central and local government. During the 1980s, government bonds, issued by the Ministry of Finance (MoF), were placed as a form of taxation, and were not tradable. The branches of international trust and investment corporations were established in China during the 1980s. These corporations helped accelerate local government development and they benefited from special exemptions from central government control. Subsequently the central government introduced greater regulation controls designed to ensure that corporations issuing bonds in the future would be able to cover due interest payments. Bond issues by the MoF climbed sharply after 1997 since the central government made a fiscal stimulus plan designed to prevent sharp economic recession during the deflation between 1996 and 2003. This method was again applied following the 2008-2009 fiscal stimulus to prevent against the contraction during the financial crisis between 2007-2008.

In terms of availability, China's bond market remains largely restricted to state corporations. Corporate bond issues fell sharply in the early 1990s, but have started to rise again in recent years. The scope for corporate bonds has expanded since 2005 when firms were allowed issue short term commercial paper for the first time (Naughton, 2007). By 2014, short term financing bills accounted for 4.1% of bond issues (PBC, 2015). As of June 2017, the government bond market had reached a total volume of RMB 37,159 billion or 47% of GDP, while the corporate bond market stood at RMB 14,771 billion or 19% of GDP.

2.2 SOE firms and the reform

2.2.1 Overview and performance of SOE firms

According to the annual report of China's National Bureau of Statistics (2018), in 2017 Chinese industry included 19022 state-owned and state-controlled enterprises. Other than the firms in the annual report, there are a large number of SOE firms outside the industrial sector in fields ranging from banking and insurance to hospitality. For example, the largest commercial banks (see section 2.1) are all state-owned. The largest of the industrial Central-supervised state-owned enterprises (CSOEs) reside within one or another of the approximately 110 state-owned conglomerates administered by State Asset Supervision and Administration Commission (SASAC). Nevertheless, only a small fraction of the SOEs are supervised by the central government, the majority of the SOEs are governed by local authorities. An OECD report (2009) points out that 18% of China's SOEs were directly controlled by the central government. Of course, although their numbers are in the minority, these CSOEs control the vast majority of the assets of the state-owned and state-controlled sector.

In terms of the output proportions, according to the annual report of China's National Bureau of Statistics (1998, 2014), SOEs and state-controlled enterprises contributed about 50% of industrial output. By 2004, that proportion had fallen to 38% of overall industrial output. Later, in 2017, the share of total sales revenue obtained by the state firms declined to 17.7%. In fact, the long-term decline of the SOE share of industrial assets and sales, as well as the profits, started from the year 2000. Figure 2-1 shows the return assets of China's firms between 2000 and 2014. In general, the non-state firms show a higher return on assets (ROA) than the SOE counterparts. It is worth noting that the increments in the ROA in both the SOE and non-SOE sectors from 2000 to 2007. This should be owing to the massive lay-off of workers from SOEs and subsequent sale of many of the weaker SOEs in the mid-1990s, since China was preparing to take part in the WTO in 2001. In addition, the dramatic decrement of the ROA on SOE assets should be because of the central role that SOEs played in leading China's fiscal stimulus of 2008-2009. The proportion of the SOE industry output remaining relatively constant at about 24% during the period 2009 to 2014 could be the evidence of the enlarged role China's industrial SOEs played in the post-2008 period with the associated pause in SOE reform.

Although there has been a secular decline of the ROA and output proportions in SOE firms, the key industries continue to be dominated by large CSOEs. According to the OECD report (2009), 19 of China's 20 largest companies are state-owned or state controlled. In addition, about one-third of their sales were associated with the energy sector, one-third with the finance sector, and the remaining third consisted of the engineering and construction, telecommunications, and motor vehicles and parts industries.

Fig.2.1 Return on Assets of China's Firms

Source: the Economist (2014)

2.2.2 SOE reforms

This part outlines three phases of China's SOE reform: (1) entry and competition (1980-1985), (2) "retain the large; release the small" (1995-2010), and (3) restructuring the large enterprises (2000 to present).

Entry and competition: Between the year 1978 and 1994, the number of reported firms in the industrial sector grew remarkably from 340,000 to 10 million. In 1978, the number of SOEs was 83,700, contributing 78% of China's gross industrial output; the 264,700 collective firms occupied the majority of the balance of the China's industrial sector. In 1994, among the 10 million firms, the number of SOEs had grown modestly to 102,200, the number of collectives, including township and village firms, to 1.86 million, and the number of "individual-owned" and "other" enterprises had shown an surged upward trend to over 800 million. The contribution of gross output stood at 37.3% for SOEs; collective-owned enterprises accounted for 37.3%, while the remaining 25% was produced by a tremendous amount of individual-owned and other enterprises, dominated by the "individual-owned" category defined as enterprises with 8 or fewer employees.

This rapid surge in new entry was accompanied by the growing marketization of China's domestic economy through the unfolding of the "dual track system." Marketization and competition were further heightened by the liberalization of trade and foreign investment, during which China's trade ratio grew from 13% in 1980 to 38% in 1995. According to Jefferson and Rawski (1994), during this early period, by making the search for new forms technology and governance essential for survival, competition became the critical motivation of SOE reform. Absent reforms, the entry of new firms and growing competition eroded the market share of SOEs while driving their more skilled and motivated workers to transfer to non-state enterprises. Facing increasing competition and the erosion of profitability, supervisory authorities were motivated to introduce management reforms. Groves et al (1994) argue that the efficiency of reforms was designed to incentivize managers through material rewards and increased autonomy. By 1995, within the population of SOEs, winners and losers had begun to emerge demonstrating the ability of the reform of managerial incentives to make a difference in the productivity and profitability of state-owned enterprises.

Retain the large; release the small: Following 1995, largely driven by the determination to ready China for accessing the WTO, China initiated two transformative reforms. The first was the 'furlough' of workers, which led to the dramatic layoff and decline in the size of the SOE workforce. Between 1995 and 2001, the year China joined the WTO, the number of jobs in the urban state sector fell by 36 million—or from 59% to 32% of total urban employment (The Economist, 2011). The second initiative was the "retain the large; release the small" initiative in which the State Council endorsed a policy to retain the large SOEs while authorizing the transfer outside the state sector of the majority of smaller SOEs. In 1997, the State Council approved a huge shift of ownership from the central government to municipalities with the explicit goal of expediting conversions to non-state ownership. The number of above-scale state-owned and state-controlled enterprises had fallen from 118,000 in 1995 to 24,961 in 2004. The result of the "retain the large; release the small" policy initiative has been the sale or ownership restructuring of tens of thousands of former SOEs. While most of the smaller SOEs were completely privatized, with ownership transferred to managers, workers, or private investors, among the larger SOEs, forms of mixed ownership evolved in which the state retained majority ownership and control. According to Gan (n.d.), "between 1995 and 2005, close to 100,000 firms with 11.4 trillion RMB worth of assets were privatized, comprising two-thirds of China's SOEs and state assets and making China's privatization by far the largest in human history."

This second reform period also saw the emergence of growing merger and acquisition activity. According to Jefferson and Rawski (2002), the development of a market for China's SOEs resulting in the transfer of state-owned assets. These authors record the development and edict of laws, regulations, and policies that served to clarify the ownership rights of state-owned assets and further enabled their sale and exchange among state agencies and private actors within China's emerging market for the sale, merger, and acquisition of corporate assets.

Restructuring the large SOEs: The reform of China's centrally state-owned and state-controlled enterprises has proceeded along two important directions. The first is their consolidation into a limited number, approximately 110 large enterprise groups. According to the OECD report (2009), China's 20 largest companies include 19 state-owned or state-controlled firms, the latter publicly traded on international exchanges. Among the Chinese companies on Fortune Global 500 list, 98 companies are based in China, including those headquartered in Hong Kong (Fortune, 2015). That places China second only to the US., which has 128 companies on the list. Comparing these 2015 figures with the recent past, China’s rise is even more striking. China had just 46 companies appearing on the list in 2010 and only 10 in 2000. However, the US has trended in the other direction: 139 American companies made the list in 2010 and 179 in 2000. Notably, the top 12 Chinese companies are all state-owned; of the 98 Chinese companies on the list, 22 are private.

The second on-going reform, associated with the first one, is the increasing concentration of SOE assets and business activity in a limited number of sectors that are most closely related to the public and corporate responsibility goals set forth by SASAC. Among China’s largest companies, approximately one-third of the SOEs are in the energy sector, another one-third are in the finance sector, and the remaining one-third are largely distributed over just three other industries. Actually, SOEs are still pervading the Chinese economy, extending well outside the industrial sector. The impact of the SOEs on private enterprise is becoming more damaging as the economy’s growth slows.

In the year 2015, China’s State Council issued guidelines that update and extend the government’s effort to achieve meaningful reform of its SOEs. One of the highlights is the SOEs will be market-based and stick to commercial operations. In fact, this point conveys a puzzle, since these SOEs can be simply privatized rather than holding by the SASAC, or the State Council. Leutert (2016) provides a reasonable explanation. This author suggests these commercial firms would be likely to continue to support various aspects of public policy goals, such as fostering innovation, supporting social stability, and advancing key economic initiatives, such as the Silk Road “One Belt, One Road” initiative.

Chapter 3 - The role of working capital management in firms’ export decisions

3.1 Introduction

Financial constraints are usually taken into account when studying the firm level behaviors. Many studies point out that financial constraint can obstruct a firm’s real decisions in many aspects. For instance, Fazzari et al. (1988) find that the liquidity constrained firms show higher investment-cash flow sensitivities than the non-constrained firms. Apart from the field of firm’s investment, financial constraint can also be an obstacle to the inventory (Carpenter et al, 1994; Guariglia, 1999), research and development (Hall, 1992; Guariglia and Liu, 2014), as well as employment (Nickell and Nicolitsas, 1999; Chodorow-Reich, 2014). Hence, the research mentioned above shows that financial constraint can affect the majority of firm-level activities. One reason to explain why financial constraint is associated with firm’s real activities is that firms facing financial constraints have difficulties in accessing external finance. Due to the pecking order theory of financing costs (Myers and Majluf, 1984), these firms have to mainly rely on their own internal finance. Being unable to choose their optimal capital structure, they are unable to make optimal decisions on their real activities.

Hence, in order to alleviate the level of financial constraint, firms may choose to adjust the level of their fixed investment. However, one feature of the fixed investment is irreversibility. To be more specific, when firms plan to reverse an investment decision, they will find that there is a huge difference between the purchase price and the resale price of the capital goods. This problem is severe when capital goods are industry specific (Bloom, 2007 and Bloom et al., 2007). Hence, firms may choose to adjust the working capital for the mean of accumulate internal funds. Working capital is the difference between the current assets and the current liabilities. The current assets consist of cash, accounts receivable, inventory, marketable securities, prepaid expenses and other liquid assets, which are all easily converted to cash. Fazzari and Peterson (1993) conduct an investigation of US firms and find these firms can effectively use the working capital to smooth out the cash flow fluctuations. Other than adjusting the working capital as a whole, the adjustment of components of working capital is also eligible for firms to relieve their liquidity constraint. For instance, Carpenter et al. (1994) also employs the US firm data to find that the disinvestment of inventory has a positive effect on accumulating cash flow. Brown and Petersen (2011) show that US firms can use the cash reserve to smooth the R&D investment, which is highly irreversible. In terms of the developing countries, Ding et al. (2013) employ a similar method to that in Fazzari and Petersen (1993) and find that Chinese manufacturing firms with relative higher level of working capital may choose to use working capital to allow for alleviation in the presence of cash flow shocks. The short survey of studies shows that working capital management is a feasible way to alleviate liquidity constraints.

However, when we review the studies between the financial constraint and export activity, we found that the research is mainly focused on the cross-country or country level. For instance, Manova (2008) finds that the financial market liberalization is usually associated with greater exports, especially for the financial vulnerable sectors. The number of firm-level research papers in this field is relatively low. Berman and Héricourt (2010) indicate firms will have chance to enter the export market if they can access external finance. Feenstra et al. (2014) find that the exporters may exhibit higher level of financial constraint due to the bank tightening the lending to exporters.

For the export firms, apart from the financial constraint, there is another crucial factor which may impede firms participating in the export market: sunk cost. Roberts and Tybout (1997) point out that sunk cost has a hysteresis effect for firms' entrance to the export markets. Melitz (2003) further finds that only the high productivity firms, or firms that can afford to cover the sunk cost, could enter in the export market. Das et al. (2007) also find that the small firms will be more affected by the sunk cost. Therefore, it is worth studying how can firms overcome the sunk cost when they are facing liquidity constraints.

In addition, when we study Chinese firms, we are interested in how the Chinese exporters can overcome the sunk cost during the export activities. The reasons can be found as follows. Firstly, from the macro level, Allen et al. (2005) find that, despite the poor financial system in China, the Chinese economy grows at a very high rate. In addition, Cull et al. (2009) point out that accessing external finance may not play an important role in explaining China's growth. Secondly, at the firm level, Guariglia et al. (2011) find the majority of Chinese firms are facing a high level of financial constraint, and they choose cash flow for the precautionary motivation. Thirdly, the literature discussed above shows that sunk costs are essential for the new exporters. In that case, compared with their non-export counterparts, the exporters need to increase their fixed investment to pay sunk costs. Considering the imperfect capital market, the non-constrained firms may be constrained during this period, while the constrained firms may face more severe financing constraint than usual, especially the private firms in China since it is hard for them to access the external finance. In that case, the most feasible way for Chinese exporters to alleviate the liquidity constraint is by turning to the internal funds. As mentioned above, the working capital method is one eligible method to mitigate the cash flow shock, including the payment of the sunk cost.

In the real business, some financial institutions provide service to help firms to be exporters. For instance, the China branch of the city bank provides a series of solutions and services to potentials exporters. These solution are mainly focus on twofold: the export credit agency, as well as the suggestions and guidance in firms' working capital management (City bank, 2019).

From the discussion above, we can see that working capital management may affect the firm's export decisions. In short, the majority of Chinese manufacturing firms may face liquidity constraint when they want to be exporters, and they may use working capital investment to alleviate this. Hence, our main research question is: for Chinese firms, can working capital investment help the firm export?

This chapter tries to answer the question above. Specifically, we construct a binary probit model to investigate the relationship between working capital sensitivity and export decision at firm level. Empirically, we divide the firms into several groups by export status (successful, new, switch and exit exporters) and ownership (SOE, private, foreign and collective) and estimate the probit model by maximum likelihood method. The data is from the annual survey conducted by the National Bureau of Statistics (NBS) of China. The panel we used contains around 37,000 non-listed firms and more than 270,000 observations from 2000 to 2007.

Using the data above, first, we find that the new exporters rely most on the working capital investment to promote the export probability among different status of exporters. The continuous exporter group (including successful and new exporters) shows the stronger effect of the working capital investment on the export than that in the switch exporter group. The exiters do not show such an effect since their level of working capital investment is relatively low. Another possible reason for the exit exporters to quit the international market is their poor performance. Furthermore, the SOE exporters are not sensitive to the working capital investment. For the other ownerships, private firms most rely on the working capital investment while the foreign firms rely least on that. In addition, we also find that only firms with relative high level of working capital can use it to promote export since the marginal adjustment cost is low.

The main contribution of this chapter is that we provide a mechanism for financially constrained firms to overcome the sunk cost during export by using a source of internal funds. In previous studies, Melitz (2003) only points out that sunk cost will impede firm's export activity theoretically. Berman and Héricourt (2010) indicate that a firm can access the external finance to overcome the sunk cost. In this chapter, we explain that firms can also overcome the cost by using the internal funds effectively.

The remainder of this chapter is organized as follows. Section 3.2 is the literature review, including the classical financial constraint literature and research on the export decision at firm level. Section 3.3 describes the data we use and also presents the descriptive statistics. Section 3.4 provides some stylized facts about the financial constraint level faced by the sample firms and their working capital management abilities. Section 3.5 discusses the baseline specification, and the empirical estimation methodology. Section 3.6 reports our main empirical results and the robustness tests and eventually section 3.7 is the conclusion.

3.2 Literature review

3.2.1 Financing constraint and working capital investment

Fazzari and Peterson (1993) argue the working capital can also be the buffer when a firm faces cash flow fluctuation since its store of liquidity is readily reversible. To be more specific, the working capital can be a source of funds, which can relax short-term financing constraints. Then, these authors choose the database described in Fazzari, Hubbard and Peterson (1988) to be the data sample. In terms of the estimation methodology, they employ the reduced form model in FHP (1988) and add the explaining variable ($\Delta W/K$) to verifying the hypothesis. The results in their Table 3 (Fazzari & Peterson, 1993, 336) show that the coefficient of ($\Delta W/K$) is negative, and the value of low-dividend firms (-0.43) is smaller than that of high-dividend firms (-0.18). This can be interpreted that the working capital has a negative effect on the firm's fixed investment, indicating that working capital can be used to alleviate the financing constraints. In addition, the difference of coefficient value between the low-dividend firms (which can be regarded as constrained firms) and high-dividend firms (unconstrained firms) implies that the constrained firms have more incentive to adjust their working capital when it is difficult to access the external finance.

The classic literature proposes good research questions and makes good model specification, however, the samples are usually the listed firms in developed economies. Compared with the private firms, they are less likely to be unconstrained. Hence, it is essential to employ the private firms for the investigation of this topic. This situation is especially worth investigating in China, since Chinese economy has experienced one of the fastest growth rates in the world since the late 1970s; and, especially, because this growth has been driven by the rapid development from the private sectors. (Allen et al., 2005). However, a remarkable aspect of Chinese economy is that China's financial market is more undeveloped than its miraculous economic growth, especially in the failure to provide funds to private firms. Hence, one question appeared: how can the private sectors in China overcome, or cope with the status of financing constraint and obtain this rapid growth? Hale and Long (2011) first proposed the argument that the private firms can manage their inventory and the account receivable (both of them are parts of the working capitals) in order to reduce the demand of external finance. In this paper, they first compare the key financial variables (e.g. leverage, financial expense over total expense ratio, and interest burden) between the State-owned enterprises (SOEs) and private firms, and then make regressions between these financial variables and indicators related to firms' size and profitability. Both the descriptive statistics and empirical results imply that the private firms are overall more constrained than their SOE counterparts in China while some biggest private firms can easily obtain external funds like the SOEs. Secondly, they study the relationship between firms' access to external funds and the ratios of inventories and accounts receivable to sales. After controlling the heterogeneity of firms, the descriptive statistics still indicate these two ratios are much lower in private sectors than in other ownership types. Secondly, the paper employs both cross-section and fixed-effects regression between these two working capital variables and the financial variables (as indicators of firm's financial constraint level). The empirical results indicate that not only do firms with less access to external finance have lower ratios of the two working capital variables, but also the firms make active adjustments in the working capital when credits are tightened. In addition, the empirical results also illustrate that the firms in more financially vulnerable sectors have more incentive to adjust their inventories and account receivables. Finally, Hale and Long (2011) make regressions between the working capital variables and the firms' productivity and profitability, and prove that the lower inventory makes the production process more efficient, which leads to higher productivity. In addition, lower accounts receivables lead firms to lower financial costs. Hence, higher productivity and lower financial costs increase the profitability of firms. To conclude, these authors find that some Chinese private firms can adjust their working capital without harming their productivity and profitability to overcome the shortage of the external finance.

Following Hale and Long (2011), Ding et al. (2013) employ a similar econometric model to Fazzari and Peterson (1993) and find that Chinese firms with some special characteristics (i.e. small, young and most financially constrained) may tend to adjust the working capital more actively. To be more specific, these authors select 116,724 firms between 2000 and 2007, covering the mainly unlisted manufacturing and mining firms in China. In order to investigate the different working capital management behaviors among the firms, the sample is divided into four sections (SOE, foreign, private and collective) by different type of investors. Regarding the estimation methodology, the regression model is similar to the baseline specification in FHP (1988), while Q is replaced as the interaction between time dummies and industry dummies, following the previous literature (Brown et al., 2009; Duchin et al., 2010 and Guariglia et al., 2011). In order to test whether the working capital can be adjusted with lower costs than that of the fixed capital, this paper also uses the investment in working capital (IWK/IK) to be the dependent variable. In the empirical parts, these authors first runs the two baseline specifications above and finds that, excluding the SOEs, all the other kind of firms faced significant financing constraints and their working capital investment sensitivity is significantly higher than their fixed investment sensitivity. Then they divide the firms into two sub-samples based on the size of their working capital: high working capital group (HIGHWK) and low group (LOWWK). Then they run the regression again. The empirical results (Ding et al., 2013:1498) confirm the arguments in Fazzari and Peterson (1993) that only firms with more working capital may be able or more willing to adjust the working capital in order to buffer the negative cash flow shocks. Then, in order to better identify how the firm's heterogeneity can affect the working capital management, the paper follows the method of Hovakimian and Hovakimian (2009) to create new fixed-investment cash-flow sensitivities (FKS) and working capital-investment sensitives (WKS) to make a distinction among each sub-sample. This part of the analysis drops the sample from SOEs since they have proved non-financial constraint in the previous regressions. The descriptive statistics show that firms with low FKS usually have higher investment in fixed capital, which means low FKS firms have better financial health than the high FKS firms. In terms of WKS, the high WKS firms can afford to adjust working capital investment during the shocks of cash flow. When combining the FKS and WKS, statistics indicate that the firms with low FKS and high WKS (short for LH firms, usually the smaller and youngest firms) are more constrained than the other kinds of firms, but they have the highest fixed investment to capital ratio. The subsequent multinomial logit regression confirms this finding: the LH firms are the most financially constrained group, while they have the highest fixed investment ratio; we can conclude that these small, young and financially constrained firms have more incentive to adjust working capital to mitigate the shock of liquidity.

3.2.2 Financial constraints, costs and firm's export decision

3.2.2.1 Relationship between financing constraint and firm's export activity

Export in international trade is defined as the activity of shipping the goods or services out of the home country to other markets, and the seller of goods can be referred to as the exporter. Currently, the literature linking the financing constraint and the firm's export may be categorized in two: a) financial variables or conditions play an important role in firm's export decision. b) exports can improve the firm's financial health.

In terms of financial factors impacting on firms' export decisions, one of the most influential research papers is that of Manova (2008). This author realized that allowing foreign investment into the domestic financial market (i.e. financial market liberalization) will reduce the cost of capital in liberalizing economies, increase investment and raise exports. Also mentioned is that, if the credit constraints restricts a firm's ability to produce and grow, financial market liberalizations will stimulate aggregate exports by allowing more firms to be exporters or by increasing firm-level exports. Hence, Manova (2008) employs 91 country-level samples from 1980 to 1997 and applies both difference-in-difference and event study method to test for the effect of equity market liberalization on trade. The paper uses a dummy variable that equals 1 after an equity market liberalization and interacts it with industry-level measures of asset tangibility and external financial dependence. In the empirical parts, the paper first carries out the impact of liberalizations on worldwide exports by sector for all countries. The empirical results show that the equity markets are associated with greater exports, especially in sectors intensive in external capital or soft assets (see table 3.2, Manova, 2008:39). Then the paper selects 39 countries with liberalized foreign investment flows during the sample period and has the same finding. This also implies that this finding is not driven by cross-sectional differences between countries with open and closed stock markets, but can be attributed to the financial reform. Using the event study method, the paper examines the change in exports around liberalization events. The finding is in line with the previous one: exports grow disproportionately faster in financially vulnerable sectors after the equity liberalization. The econometric results also show that, after three years of liberalization, some financial-vulnerable sectors' exports increase 13% more than their less vulnerable counterparts. In addition, comparing the value traded as a share of GDP, it can be seen that the liberalization may compensate for an underdeveloped domestic financial markets. Finally, when linking the trade openness and the financial liberalization, the paper finds that exports increase after equity market reforms even in the sample of countries that liberalized their stock markets but not trade flows. In addition, it also implies that the equity market liberalizations have stronger effects in countries with more strict trade policies, which indicates that the impact of increased access on external finance is greatest when trade costs are high.

Feenstra et al. (2014) believe that the productivity of the export firms is unobserved by the banks since firms should accumulate working capital prior to production. Hence the banks will tighten the lending channel to the exporters, implying that the export companies may face more severe constraint than general firms. These authors estimate a structural model incorporating the exporting and loan decisions and find that the credit constraint becomes tighter when a firm's export share grows, implying that the credit constraint strengthens the productivity selection channel.

Berman and Héricourt (2010) estimate the effect of financial constraints on both extensive and intensive margin of trade. The database is a cross-country firm-level database containing 5,000 firms in 9 developing countries. The results stress that, if firms can access finance, it will lead them to the export market. Nevertheless, once a firm enters the export markets, the better financial health cannot help to increase the volume, nor the period of remaining as an exporter. In addition, the productivity is positively related to the access to finance. However, the relationship between productivity and exporting only appears above a given threshold of access to finance (Berman & Héricourt, 2010:211).

3.2.2.2 Sunk costs and the firm's export decision:

Sunk cost, according to Baldwin and Krugman (1989), can be defined as the difference between the entry cost for firms entering a new foreign market and the fixed maintenance cost for firms remaining in this market.

Baldwin (1988) is the first researcher to investigate the sunk cost effect in the international trade market. Based on occurring sunk cost when firms enter the foreign market, Baldwin (1988) augments a simple firm model from Spence (1976) and Dixit and Stiglitz (1977) to show that a certain level of appreciation of domestic currency may change the structure of domestic markets, which may lead to the hysteresis effect of the international trade flows.

Roberts and Tybout (1997) employ the Colombian manufacturing firms in major exporting industries between the period 1981-1989 to test for sunk-cost hysteresis by directly analyzing entry and exit patterns. In order to do this, these authors develop a dynamic discrete-choice model that expresses each firm's current exporting status as a function of its previous exporting characteristics affecting the future profits from exporting and unobserved shocks. The theoretical model implies that, if the sunk cost exists, it will directly affect the firm's export participation condition (i.e. the incurred sunk cost means that the firm will not be likely to export in the current period). In the empirical results, the coefficients of three lags of the firm's past participation status indicate the existence of the sunk cost, and the latest year's exporting status has the strongest positive effect on the probability of exporting this year. Further estimation also indicates that the sunk cost and profit expectations play a crucial role in shaping behavior of export activity. In addition, these authors also report that the export profitability varies from the firm's heterogeneity. Specifically, the longer and older firms may obtain better profitability; this is in line with the economic-scale theory.

Based on the above mentioned literature of the sunk costs, Melitz (2003) is the first to take the sunk cost into account in a structural model. This author provides an extension of Krugman's (1980) trade model that includes different levels of firm productivity. For the relationship between export decision and sunk cost, Melitz proves that the export market entry is costly and the firms will only decide to export once they find out their productivity level. The model incorporating the sunk costs can be expressed and explained as below.

First, it assumes that all the exogenous factors impacting firm entry, exit and productivity is not changed by trade. Before entering the export market, firms have the same *ex-ante* productivity distribution $g(\varphi)$ and bad shock probability δ. In a stationary equilibrium, any firm in the market with productivity φ gains variable profits $r_x(\varphi)/\sigma$ (σ is the residual demand curve with constant elasticity for this firm) in each period from the export revenue to any given country.

Another assumption is that the export cost is equal across countries and the firm will choose to either export to all countries, or never export. Given that the export decision occurs after firms gain knowledge about their productivity level φ, firms will be indifferent between paying the one-off investment cost f_{ex}, or paying the amortized per-period part of the cost $f_x = \delta f_{ex}$ in each period. The per-period profit flow of any exporting firm then reflects the per-period fixed cost f_x, which is incurred per export country.

Since no firm will ever export and not also produce for its domestic market, each firm's profit can be divided into parts earned from domestic sales, $\pi_d(\varphi)$, and export sales per country, $\pi_d(\varphi)$, by accounting for the whole overhead production cost in domestic profit:

$$\pi_d(\varphi) = \frac{r_d}{\sigma} - f \ , \qquad \pi_x(\varphi) = \frac{r_x}{\sigma} - f_x \tag{3.i}$$

Hence, the revenue of the firm is expressed as: $\pi(\varphi) = \pi_d(\varphi) + \max\{0, n\pi_x(\varphi)\}$, where n denotes the number of foreign countries. The value of each firm can be written as: $v(\varphi) = \max\{0, \pi(\varphi)/\sigma\}$. And the cutoff productivity entry level is: $\varphi^* = \inf\{\varphi: \varphi \geq \varphi^*, \pi_x(\varphi) > 0\}$.

In this case, when the τ is assumed as the marginal cost of the firm, it can be found that the firms will turn to the export market if $\tau^{\sigma-1} f_x > f$. In addition, when there exists a large enough fixed export cost $f_x > f$, the firms will also enter into the export market.
According to Melitz (2003), the zero cutoff profit (ZCP) condition describes the relationship between the average revenue level $\bar{\pi}$ and the average productivity level $\tilde{\varphi}$. In an open economy, the zero cutoff profit can be written as:

$$\bar{\pi} = \pi_d(\tilde{\varphi}) + n\pi_x(\widetilde{\varphi_x}) = fk(\varphi^*) + nf_x k(\varphi_x^*)$$

(3.ii)

From Melitz (2003: 1703), we can learn that the first part of the right side (i.e. $\pi_d(\tilde{\varphi})$ or $fk(\varphi^*)$) is the ZCP condition in the closed economy. Hence, it is obvious to see that, in an open economy, international trading improved the cutoff entry productivity level and the average revenue level of firms. In addition, from the equation above, one explanation for the ZCP curve shifts up is that the existence of sunk cost (f_x) during the export activities.

Following Melitz (2003), Das et al., (2007) extended the firm-level heterogeneity and adding the export profits, uncertainty about the determinants of future profits and sunk costs. This model emphasizes that the entry costs make producers' export supply responses dependent on their previous exporting status since they need to bear the sunk costs prior to the first exportation. These authors employ the firm level data on three Colombian manufacturing industries and first estimate the value of sunk costs in the literature. The level of sunk costs is substantial and interesting: for the small exporters, the average sunk costs are around $430,000 while the costs for the bigger firms are less than $400,000. The bigger size exporters face lower entry costs, which imply the entry cost is a heavy shackle for the SMEs. Finally, the empirical results indicate that the potential exporters do not begin to export unless the present value of their expected future export can overcome their sunk costs, and the successful export firms may continue to export even the current profits are negative, avoiding the reestablishing sunk costs if they opt out the international market now and then re-enter it in the following years.

3.2.2.3 Other factors which decide the firm's export entry and self-selection export theory.

Beside the relationship between sunk cost and the export entry, there are a series of other firm-level factors which may decide the market entry decision. The first one is size. Previous studies indicate the size can significantly affect the firm's export decision (Bernard & Jenson, 1999; Farinas & Martin-Marcos, 2007; Greenaway & Kneller, 2007; Marinov et al., 2008). To be more specific, Bernard and Jenson (1999) employ firm-level data of US manufacturing industry between 1984-1992 and find that, prior to being exporter, the potential exporters have 20%-45% more employment than the non-export counterparts. In terms of the UK manufacturing firms, the situation is similar. Farinas and Martin-Marcos (2007) employ 3,151 Spanish firms from 1990 to 1999 and indicate the exporters are above five times as large as that of non-exporters in terms of employment level. Greenaway and Kneller (2007) use 11,225 UK firms from 1989 to 2002 and observe that, compared with the non-exporters, the exporters have 12.6% employment on average. Rather than using the number of employments as the proxy of firm size, Marinov et al. (2008) employ productivity to be the proxy of firm size. Their database consists of 110,196 French firms for the years 1993 through 2002, divided into 20 categories by size. The descriptive statistics indicate that the distribution of new entrance exporters increases with the size. Regarding to some developing countries, the size effect also applies. Clerides et al. (1998) employ Colombian, Mexican and Moroccan firms between 1981 and 1991 in their database and observe that firms with lower marginal cost and larger capital stock are more likely to start to export.

The second factor is wage (Bernard & Jenson, 1999, Greenaway & Kneller, 2004). Apart from the size effect, Bernard and Jenson (1999) also find that, for the US new exporters, their average salary payment is higher (2.60%-4.41%) than that of the non-exporters before export market entry. The UK exporters have a wage premium bigger than the non-export counterparts, but the premium volume (0.5%) is not as high as that of US manufacturing exporters (Greenaway & Kneller, 2004). Compared with US and UK firms, Spanish firms have a higher salary wedge between exporters and non-exporters: the exporters pay 35% more wages than their counterparts (Farinas & Martin-Marcos, 2007).

The third factor is productivity. As mentioned above, the theoretical framework indicates that only the most productive firms can access the export market (Melitz, 2003). It can be predicted that firms with high productivity will have more chance to be exporters. Bernard and Jenson (1999) divide the sample period (i.e. 1984-1992) into two sub periods (i.e. 1984-1988 and 1989-1992) in order to match the firm waves and exporter booms. For the new exporters in any of the time periods above, they exhibit a higher output level than the non-exporters. Greenaway and Kneller (2004) obtain similar results among UK firms. Specifically, the UK exporters have higher output (20.8%), labour productivity (2.2%) and Total Factor Productivity (TFP hereafter) (9.7%) than the non-exporters. Farinas and Martin-Marcos (2007) point out the Spanish exporters exhibit higher performance both in TFP (0.5%) and labour productivity (53%) than the non-exporters. With respect to the research among developing countries, this point is also proved by econometric evidence. Using the firm-level data from Chilean manufacturing firms, López (2005) finds that, without affecting their shares in the domestic market, the new exporters exhibit higher levels of both productivity and investment than that of the non-exporters.

The fourth factor is the firm’s origin or ownership. In the global economy, a firm in a specific country can receive investment from indigenous investors, or from foreign investors. Firms invested in or owned by foreign investors are usually called “foreign companies”. Previous research finds that the export behaviour for indigenous firms and firms with foreign affiliation are different. To be more specific, Kneller and Pisu (2004) employs UK plant-level data and that finds firms with foreign ownership are more likely to be exporters than the domestic firms. In addition, they also point out the foreign firms are more export intensive and contribute to the overall manufacturing exports disproportionately. Sjöholm (2003) use 21,550 Indonesian firms between the year 1994 and 1997. Considering a series of export-related firm characteristics, the econometric result indicates that foreign ownership is the most significant factor for export probability. Further results also point out that a foreign network can reduce the export, but the spillover of Foreign Direct Investment cannot impact on a firm’s export decision.

From the literature mentioned above, compared with the non-exporters, the exporters display that, prior to enter the export market, they usually have some common features: larger size (both in employment and assets), higher salary level, they are more productive and foreign affiliated. In other words, firms successfully entering the export market is due to their superiority in some heterogeneous characteristics. This is in line with Melitz (2003) who states that only the best firms have the ability to enter into the market. This is the theory of self-selection. For instance, Farinas and Martin-Marcos (2007) not only find that **new exporters perform better than non-exporters prior to becoming exporters, but also indicate that continuing exporters perform better than the exit exporters. A similar case is also reported in Taiwanese firms (Aw et al., 2000, 2007).**

3.2.2.4 A controversial theory on self-selection effect: learning-by-exporting.

However, rather than the self-selection theory, some of the literature supports a reverse mechanism: firms improve their performance after entering the markets. This is because the exporters can learn from foreign markets both directly, through buyer-seller relationships, and indirectly, through increased competition from foreign producers. Girma et al., (2004) utilize the UK manufacturing firms and matching technique and find that the export firms are larger and more productive than non-export firms. However, under the matching technique between the exporters and non-exporters, these authors also reveal that productivity is enhanced after firms enter into the export market. Blalock and Gertler (2004) employ an Indonesian manufacturing panel data between 1990 and 1996 find that the new exporters increase their productivity by 2% to 5% immediately they start to export. The conclusion for the Indonesian firms is that they may have learning-by-exporting effects, and rather than self-selecting the most efficiency firms into the export market. Van Biesebroeck (2005) also uses a panel of some sub-Saharan African manufacturing firms and finds that, prior to entry the export market, the (potential) exporters clearly exhibit advantage on productivity compared to their non-export counterparts, and the level of productivity also grows after entering into the overseas market, which indicates that this author supports both self-selection and learning-by-exporting effect. For the Chinese firms, Van Biesebroeck (2014) also reveals that the Chinese exporters can raise the productivity after beginning the export activities. From the literature above, we can conclude that learning-by-exporting often take place in a developing country or in transition economies, where entering into the export market can help them learn the new technology on productivity or advanced methods on management. Even some advanced economies can also learn from export since their export destination may be the frontier of the technology (Girma et al., 2004). Another possible explanation for the learning-by-exporting effect is economics of scale. Due to the deficient of demand or the impact of political affiliation, firms focusing on selling at domestic markets may not achieve the level of their scaled economy. However, with the expansion of the sales, being an exporter can help them realize this level (Van Biesebroeck, 2005 and 2014).

3.2.3 Gaps and hypotheses

From the above-mentioned literature, one obvious obstacle can be seen: when firms choose to enter the export market, they need to pay different forms of sunk costs. Usually, prior to breaking into the foreign market, firms need to learn about unfamiliar foreign markets, investigate and develop potential marketing channels, and adjust their products in order to fulfill the demand from foreign customers and some relevant regulations. (Melitz, 2003). These sunk costs are essential for the new exporters. During the export preparation period, excluding the investment for normal operation, the new exporters need to increase their fixed investment to pay sunk costs. In that case, considering the imperfect capital market, the non-constrained firms may be constrained during this period, while the constrained firms may face more severe financing constraint than usual, especially the private firms in China since it is hard for them to access external finance. However, the research on working capital management (see Fazzari and Peterson (1993) and Ding et al. (2013)) indicates that constrained firms have more incentive to adjust their working capital when facing constraint. Regarding the Chinese firms, the small and fast-growing firms are more likely to adjust the working capital when the cash flow fluctuates (Ding et al., 2013). Hence, in order to overcome the sunk cost, it is reasonable to assume that working capital may be used for the exporters as a source of funding to alleviate the liquidity constraint. Therefore, investing in working capital may contribute to firm's export participation. However, this is a gap in the literature and this chapter will try to make contributions to fill this gap.

Based on the literature and the discussion above, we develop the hypothesis of this chapter as below.

Hypothesis 3.1: exporters can use the working capital to overcome the sunk cost.

Hypothesis 3.2: the efficiency of using working capital may vary among exporters in different status. The successful exporters may exhibit higher ability than the switch exporters.

Hypothesis 3.3: the efficiency of using working capital may also vary among firms with different ownership. The non-SOE firms would outperform than the SOEs.

Furthermore, Ding et al. (2013) point out that, for the financially constrained firms, only firms with high level of working capital are more willing to adjust the working capital in the presence of fluctuation of liquidity, since the marginal value of working capital is relatively low. Similarly, the firms with low level of working capital may unable to adjust it since the marginal value is high. Hence, we differentiate the working capital investment ratio across firms with relatively high and low working capital. Hence, based on Ding et al. (2013), we propose the Hypothesis 3.4 as below.

Hypothesis 4: firms with higher level of working capital are more likely to use it to overcome the sunk cost.

3.3. Data and descriptive statistics

Our data are collected from the annual accounting reports filed by industrial firms with the National Bureau of Statistics (NBS) over the period 2000–2007. All state-owned enterprises and other types of enterprises with annual sales of five million yuan (around $650,000) or more are covered. These firms operate in the manufacturing and mining sectors and are in all 31 Chinese provinces or province-equivalent municipal cities. We drop observations with negative sales, negative total assets minus total fixed assets, and negative accumulated depreciation minus current depreciation. We also eliminate firms that do not have complete records on our main regression variables. In order to control for the potential influence of outliers, we clip observations in the one percent tails of each of the regression variables. Finally, following Greenaway et al. (2007), Harris and Li (2011), and Dai et al. (2016), based on the export dummy variable, we separate the sample into five parts: successful exporters, new exporters, switch exporters, exit exporters and non-exporters. The successful exporter sample consists of the firms which continuously export over the period. Correspondingly, the non-exporters sample is the firms that never export in this period. The new exporters indicate the firms turn to start export in the observation period, with continuous export records onwards. The switchers indicate firms with some export records, but not continuous. For instance, a firm in this group may have export records in the year t-1 and t+1. However, it chooses to exit the export market in the year t. The exiters are firms who terminate their export activities in the observation period. Compared with the firms in the switch groups, the exit exporters may have continuous export record, but eventually they exit the market during the observation period. Compared with the switchers and exit exporters, the successful and new exporters can be regarded as "continuous exporters". That is because they exhibit continuous exportations during the observation period. Specifically, the successful exporter may have started exportation before 2000, which indicates they may have a longer export record than 8 years.

The NBS database contains information on the fraction of paid-in-capital contributed each year by the following types of investors: the state; foreign investors (excluding those from Hong Kong, Macao, and Taiwan); investors from Hong Kong, Macao, and Taiwan; legal entities; individuals; and collective investors. Legal entities include both state legal entities and private legal entities. **Collective** investors represent communities in urban or rural areas, managed by local governments. According to Guariglia et al. (2011) and Ding et al. (2013), we group investors from Hong-Kong, Macao, Taiwan, and other parts of the world into a single category (which we label **foreign**); and legal entities and individual investors into a category labeled **private**. The question here is that some of the legal entities also include state-owned legal entities, it may not be appropriate if we include these entities into the private category. Our database cannot allow us to make distinction between the state legal entities and private legal entities, which indicates we cannot exclude the former from the private category. However, the literature points out that the state-owned legal entities are also profit-oriented (Wei et al., 2005), which means it may be proper to regard these firms as private firms. We then classify our firms into state-owned (**SOE**), foreign, private, and collective, on the basis of the average shares of paid-in-capital contributed by the four types of investors over the sample period, making use of a majority rule. For instance, we classify a firm as private if the average share of its paid-in capital contributed by the legal entities and/or individual is at least 50%.

In addition, the threshold (i.e. the annual sales of $650,000) of the NBS database may occur to a survivorship bias. Therefore, it is essential to briefly discuss this issue. There are some reasons which make us believe the survivorship bias is minimized. Firstly, the $650,000 threshold is not a hard rule. According to the China's National Bureau of Statistics (2004), some small firms (i.e. firms with annual sales less than $650,000) are included into the database if they have a high level of profit given the level of employment. This is an effective way to reduce the sample selection bias based on the threshold. Secondly, if sales threshold is strictly carried out, firms that are in the sample one year, but whose sales dropped below the threshold the next year, are no longer required to report to the annual survey. In fact, many of those firms continue their reporting and they are not automatically removed from the sample. In total, 5% of private or collectively-owned firms have sales below 5 million RMB. (China's National Bureau of Statistics, 2004 and 2008). Thirdly, Brandt et al. (2014) make a comparison of some important variables between the NBS database and the China statistical Yearbook. From the year 1998 to 2007, the differences between the two panels are around 0.1%.

Table 3.1 shows the number of firms and observations among our five samples. In total, the five panels cover 37,302 unlisted firms, which corresponds to 273,341 firm-year observations. All the panels are unbalanced since we have eliminated outliers which may affect the empirical results. Table 3.1 also partially reflects the export behavior among the different kind of firms. For the successful exporters, foreign firms occupy the largest proportion (54.27%) while the fraction of private firms is not far behind (28.55%). The SOEs and collective firms only occupy 7.28% among the successful exporters. In terms of the new exporters, the largest fraction is the private firms (61.95%), followed by the foreign firms. The SOEs and collective firms still occupy the smallest proportion. In terms of the switch and exit exporters, the ownership distribution is similar to that of the new exporters: the biggest fraction is the private firms, followed by the foreign firms, while the SOEs and collective firms occupy the smallest percentages. Compared with the distribution of that in the non-export counterparts, the fraction is interesting: private firms still occupy the biggest proportion (64.10%) while the SOEs and collectives exhibit a similar percentage (13.30% and 15.88%, respectively). However, the smallest scale is the foreign firms (6.70%). Considering that the private firm is the largest fraction (70.3%) in the original NBS database we employed, the large percentage of private exporters is reasonable. In addition, the proportion of the foreign firms among the three panels may reveal that the foreign firm may be the most incentive category to being an exporter.

Table 3.1 Number of firms and observations for the samples

	Continuous		New		Switchers		Exiters		Non Exporters	
	firms	Obs.	firms	Obs.	firms	Obs.	firms	Obs.	firms	Obs.
Overall	10068	75667	2548	18784	4821	35202	1977	14400	17888	129288
SOE	388	2801	156	1124	329	2331	186	1242	2380	16703
Private	3875	28587	1551	11638	2729	20370	1081	8064	11467	83591
Foreign	5464	37693	747	5321	1360	9545	511	3597	1199	8348
Collective	341	2856	94	701	403	2956	199	1497	2842	20646

Table 3.2 reports the mean value of the key variables for the five entire samples, which determines the firm's export participation as general characteristics. The financial characteristics captures firm's financial condition and the working capital-related variables captures the level of firm's working capital. The definition of each variable is as follows:

I/K is the ratio of fixed investment over fixed capital, which can be regarded as the level of firm's investment spending (Fazzari et al., 1988).

Assets are the sum of the firm's fixed assets, expressing firm's size. The number of employee is an alternative variable to indicate the size. The export literature indicates the larger firms may be more likely to enter into export market (Bernard & Jenson, 1999; Farinas & Martin-Marcos, 2007; Greenaway & Kneller, 2007; Marinov et al., 2008). Wages are the salary per worker and this is also a positive indicator for firms entering into the export market since it is an indicator of labour quality (Bernard & Jenson, 1999, Greenaway & Kneller, 2004).

The variable total factor productivity (TFP) and labor productivity are used to measure the firm's level of productivity. The labor productivity is calculated by the firm's real sales divided by the number of the employees. TFP is usually expressed as the residual in the aggregate output, which cannot be explained by the factor input (Massimo et al., 2008). The most common method for estimating the TFP is from Olley and Pakes (1996), which is based on a consistent semi-parametric estimator. The main idea of Olley and Pakes (1996) is employing the investment as a proxy for the unobservable shocks of the productivity. However, this could cause problems if an observation with zero investment occurs, since this would be dropped from the data. Levinsohn and Pertin (2003) develop a new method based on this problem: they introduce a new estimator employing intermediate inputs (e.g. raw materials) as proxies, which can respond more smoothly to the productivity shock. Hence, in this paper, we use the Levinsohn and Pertin (2003) method to estimate the TFP. The export literature which supports the self-selection theory indicates that the most productive firm will enter the export market (Melitz, 2003; Greenaway & Kneller, 2004; Farinas & Martin-Marcos, 2007), while some literature also argues that the exporters will enhance productivity after entering the market since they can learn the frontier of technology from the clients (Girma et al., 2004) or exhaust their scale economics since the sales expansion (Van Biesebroeck, 2005 and 2014).

In terms of the financial variable, the CF/K denotes the cash-flow over the fixed capital. The liquidity ratio is the firm's current assets minus current liabilities over total assets, while the collateral ratio of the firm is tangible assets to total assets. For these two indicators, a higher ratio indicates the firm has a better financial health. The leverage ratio is defined as the firm's ratio of short-term debt to current assets, and high leverage indicates the firm is in a poor financial condition.

For the working capital-related variables, IWK/K is the ratio of investment in working capital over the firm's fixed capital. The investment in working capital is defined as the difference between the working capital stock of end of year t and end of year t-1. WK/K is the firm's working capital over the fixed capital.

The value of general characteristics in the table 3.2 illustrates that the different kinds of exporters and non-exporters are quite from each other in some respects. First of all, the new exporters during the preparation period exhibit the highest investment ratio (16.89%), and that the ratio has fallen to 13.77% after entering into the market. This implies that new exporters are more willing to expand the size. The switchers and the exiters show a significantly lower level of I/K than the continuous exporters. Specifically, for the exiters, the I/K ratio is even lower than for the non-exporters. Secondly, in terms of the two size indicators, it can be interpreted that all the exporters show a larger size than the non-exporters. Moreover, for the new, switch and exit exporters, when they turn to export, they all show a larger size than those in the non-export periods. In addition, prior to enter the export market, the new exporters are not only larger than the non-exporters, but also larger than the switchers and exiters in the non-export period. Thirdly, regarding the wages, the general trend is that exporters pay higher wages than the non-exporters, and in the exportation years, the firms will pay higher wages than those in the non-export years. The new exporters exhibit the highest level of wages in all categories of exporters. However, the exporters pay the lowest level of wages in the exportation period, which is even lower than that of non-exporters. Fourthly, the productivity factors shows that the exporters are usually more productive than the non-exporters, and for the new and switch exporters, the productivity in the export period is higher than that in the non-export period. Hence, these two phenomena are in accordance with the learning-by-exporting effect (Van Biesebroeck, 2005 and 2014). However, the exiters again display a different situation: the productivity in the export period is lower than that in the non-export period.

In terms of the financial characteristics, the switchers in the non-export period exhibit the lowest cash flow ratio while the number of ratio in other three columns is similar. The liquidity and leverage factors display similar facts of the financial conditions among the samples. First, exporters exhibit a higher (lower) level of liquidity (leverage) than the non-exporters, indicating the exporters may face a better financial condition. Secondly, among the different types of exporters, there is a decreasing (increasing) trend of liquidity (leverage) from the most continuous exporters (i.e. successful exporters) to the least continuous exporters (i.e. exit exporters). This implies the firms with relatively continuous export record will have a better financial condition. In addition, for the new, switch and exit exporters, their liquidity (leverage) level is higher (lower) in the export period, implying that being an exporter may improve the financial health (Greenaway et al., 2007). However, the low (high) value of the liquidity (leverage) shows another fact: that all the Chinese exporters may be facing a poor financial condition. Regarding the collateral, the situation is mixed: the exports' collateral level is lower than that of the non-exporters, and the successful and new exporter's collateral is lower than that of the switchers and exiters. However, all of the four columns exhibit a high level of cash-flow ratio. This is consistent with Guariglia et al. (2011) who point out that firms in China have been able to grow at high rates in recent years despite the financing constraints that they face, because they have been able to accumulate very high levels of cash flow. In sum, the mixed results for the latter three financial factors indicate that potential exporters do not show better financial health than the non-export counterparts (Greenaway et al., 2007; Chen & Guariglia, 2013).

The last part of table 3.2 expresses the working capital-related variables. The new exporters in the non-export period have the highest investment in working capital ratio (IWK/K), and the ratio is also high after starting exportation. The successful exporters and the non-exporters exhibit similar investment in working capital ratio. For the switchers and exiters, the results are mixed. On the one hand, these two categories show a lower level of IWKK than that of the non-exporters in the non-export period. On the other hand, in the export periods, they display a higher IWKK ratio than that of non-exporters, but lower than that of the new exporters. However, when we see the working capital ratio (WK/K), the successful exporters exhibit the highest ratio in the working capital, and followed by the new exporters. The switchers exhibit a higher level of WK/K than the exiters, but the value of both groups are smaller than those in the new-exporter group. In addition, the values of working capital ratio are very high (more than 60%) in all the columns. If we combine the results from the financial characteristics and the working capital variable, we may find that firms in our sample exhibit a relatively poor financial condition, and they all have a high working capital rate. The relatively continuous exporters (i.e. successful and new exporters) exhibit higher working capital level than the switchers and exiters. Hence, we may imply that the continuous export groups may show a better ability to use the working capital management for overcoming the sunk cost, while the switchers and exiters may not use the working capital as efficiently as the continuous exporters.

In addition, from the statistics shown in table 3.2, it can be seen that the switchers and the exiters exhibit smaller size, lower wage level, lower productivity, poorer financial conditions and lower working capital stock than the successful and new exporters. Hence, this may imply that the switchers and exiters do not perform as well as the continuous exporters, which is in line with the relevant literature (see Aw et al., 2000 and Bernard & Jensen, 2007; Harris & Li, 2011)

Table 3.2 Overall descriptive statistics for the samples

General characteristics	Continuous exporters	New exp=0	New exp=1	Switchers exp=0	Switchers exp=1	Exiters exp=0	Exiters exp=1	Non exporters
Fixed investment/fixed capital (I/K)	12.57	16.89	13.40	9.33	10.91	5.07	7.69	9.88
Assets	1524.62	1108.26	1514.10	817.00	991.65	944.60	829.60	488.60
number of employees	596.22	352.70	433.42	312.80	378.84	332.60	389.70	239.70
wages	16.25	14.22	18.38	13.24	15.11	15.34	12.06	12.20
total factor productivity(tfp)	5.68	4.70	5.61	4.79	4.97	5.88	5.24	4.83
labour productivity	297.80	321.07	431.97	320.90	336.27	345.20	319.40	288.10
Financial Characteristics								
cash flow/fixed capital (CF/K)	39.45	37.39	42.11	37.35	43.52	39.73	33.42	36.38
liquidity	9.97	7.27	8.79	6.43	8.15	4.10	4.77	3.29
leverage	54.41	57.58	56.14	58.20	56.42	61.02	60.71	61.33
colleateral	31.46	33.66	30.65	34.70	32.42	30.77	32.55	35.75
Working capital-related variables								
Investment in working capital (IWK/K)	9.18	16.84	14.32	4.32	12.97	6.44	9.94	9.68
Working capital/fixed capital (WK/K)	91.65	84.81	87.41	69.28	80.33	61.23	63.97	60.63
Observations	75667	8234	11536	20915	16579	7756	7669	137948

Notes: The number of assets, wages and labor productivity are expressed in thousands of yuan and denote the mean values; the number of employees is denoted as mean values; TFP is the firm's total factor productivity calculated using the Levinsohn and Petrin (2003) method; all other variables are expressed as percentages. Exp is a dummy variable and it is equal to 1 if the firm exports while equal to 0 if the firm does not export. For all the variables, each two mean values from different sample groups have been assessed by the mean-comparison test (t-test) and the result is at least significant at 5% level. To save space, these p-values are not reported.

Table 3.3 reports the mean value of the key variables for firms with different export status and different ownerships. In terms of the I/K ratio, the overall tendency is similar with that of the overall samples: the new exporters in the NON export period can have the highest I/K ratio and the relatively continuous exporter exhibit higher I/K ratio than the non-exporters. The switchers and exiters sometimes display a lower level of I/K than the non-exporters. Specifically, the private firms exhibit highest investment ratio in all the export status while the SOEs exhibit the lowest ratio. In terms of the two size indicators among the ownerships, we find that the SOE exporters are the largest firms while the collective firms are the smallest ones, and the size of private and foreign firms are similar. Nevertheless, regarding the non-exporters, the largest one is the foreign group, not the SOE, which is unexpected. The tendency of the wages is also similar to the entire sample. To be more specific, except for the exit exporters and foreign switchers, all other export columns show higher level of salaries than those in the non-export columns, and the new exporters will increase the salary level after starting exportation. Considering the productivity, only SOE group exhibits both the self-selection and learning-by-exporting effect, the statistics in other groups (except for exiters) only seem to support the learning-by-exporting effect. Similarly, for the exiters, the productivity in the export period is lower than that in the non-export period.

In terms of the financial variables, the SOE group exhibits the lowest cash-flow ratio while the foreign group displays the highest level of CF/K ratio. For the liquidity ratio among different ownerships, the SOE group still exhibits the lowest level while the foreign group shows the highest level. In terms of the different category of exporters, the exiters still display the lowest liquidity level. It is worth mentioning that the successful SOE exporters even display a minus liquidity, and for the private and collective firms, the liquidity ratio of successful exporters is even smaller than the non-exporters. Regarding the leverage, the SOEs exhibit the highest one and the foreign group shows the lowest one. The distribution and tendency for the collateral is similar to that of the leverage. The SOEs display the worst financial condition among the groups, which implies they may benefit from the soft budget constraint (Bai et al., 2006). The foreign firms show the best financial condition, inferring that, compared with the private and collective firms, they seem to be less financial constrained. However, the high value of cash flow ratio for foreign group may be regarded as the precautionary motivation since the local banks in China are reluctant to lend to foreign firms (World Bank, 2005).

In terms of the working capital related variables, the SOE firms have both the lowest investment working capital ratio and the working capital ratio while two ratios in the foreign group exhibit the highest level. Except for the SOE group, all the other groups of exporters exhibit a relatively high level of working capital ratio. For the private and foreign firms, the new exporters still exhibit a higher working capital investment than the switchers and exiters, both in the non-export and export period. This implies that the new exporters may have better ability in using working capital than the switchers and exiters. In addition, for the SOE group, combining the financial variables and the working capital variables, we find that the SOE exporters have poor financial condition and do not tend to use working capital to overcome the sunk cost. This implies not only that they may benefit from the soft budget constraint (Bai et al., 2006), but also suggests that their exportation may not be profit-chasing activities, but in response to administrational order by the government (Bai et al., 2006).

Table 3.3 Descriptive statistics for firms by different ownership

General Characteristics	SOEs							
	Continuous Exporters	New (Exp=0)	New (Exp=1)	Switcher (Exp=0)	Switcher (Exp=1)	Exiter (Exp=0)	Exiter (Exp=1)	Non Exporters
Fixed investment/fixed capital (I/K)	6.13	13.32	8.28	2.02	4.76	-1.18	3.09	5.20
Assets	4611.00	4910.00	4388.00	1644.31	2095.97	2150.00	2116.64	671.80
number of employees	1431.00	1022.00	956.90	609.08	717.20	705.70	922.00	382.20
wages	15.37	12.91	18.60	12.44	14.40	16.09	11.73	12.29
total factor productivity(tfp)	5.87	4.65	6.03	4.45	4.83	5.70	5.09	4.44
labour productivity	212.10	198.50	323.80	179.30	225.50	202.60	145.80	142.70
Financial Characteristics								
cash flow/fixed capital (CF/K)	12.59	12.54	16.80	15.71	16.11	19.99	9.30	14.14
liquidity	-1.06	4.97	3.10	-9.69	-9.88	-8.03	-6.20	-7.17
leverage	67.49	61.41	64.24	74.18	75.18	74.00	70.28	69.68
colleateral	35.56	38.90	35.05	40.11	38.71	38.17	40.31	44.15
Working capital-related variables								
Investment in working capital (IWK/K)	1.35	-3.05	2.73	-1.08	-0.02	4.67	-2.82	2.80
Working capital/fixed capital (WK/K)	17.13	27.22	17.51	16.27	-10.49	29.31	10.57	13.46
Observations	2801	600	524	1532	799	719	523	16703

Notes: See notes in table 3.2

Table 3.3 Descriptive statistics for firms by different ownership (continued)

	Private							
General Characteristics	Continuous Exporters	New (Exp=0)	New (Exp=1)	Switcher (Exp=0)	Switcher (Exp=1)	Exiter (Exp=0)	Exiter (Exp=1)	Non Exporters
Fixed investment/fixed capital (I/K)	14.47	22.94	15.87	10.16	12.95	6.31	9.68	11.29
Assets	1416.00	844.90	1262.00	694.10	877.30	841.80	759.10	439.50
number of employees	560.90	370.60	438.90	283.70	357.60	288.30	350.80	216.50
wages	13.84	10.35	14.39	11.74	12.47	14.16	10.88	11.62
total factor productivity(tfp)	5.64	4.49	5.78	4.78	5.00	5.85	5.16	4.86
labour productivity	245.50	210.80	305.50	297.40	288.30	319.90	237.90	291.50
Financial Characteristics								
cash flow/fixed capital (CF/K)	33.06	31.13	33.33	45.15	42.11	38.33	28.86	37.93
liquidity	2.83	4.39	4.90	5.87	5.32	1.34	0.70	3.40
leverage	62.25	59.12	60.00	58.78	59.53	64.10	65.42	61.05
colleateral	30.46	35.42	30.48	34.57	32.55	30.07	31.82	34.83
Working capital-related variables								
Investment in working capital (IWK/K)	8.33	11.97	9.67	10.53	8.17	7.71	9.85	6.93
Working capital/fixed capital (WK/K)	58.46	64.79	59.31	59.75	46.81	48.81	48.30	66.25
Observations	28587	5193	6445	12416	7954	4220	3844	83590

Notes: See notes in table 3.2

Table 3.3 Descriptive statistics for firms by different ownership (continued)

General Characteristics	Foreign							
	Continuous Exporters	New (Exp=0)	New (Exp=1)	Switcher (Exp=0)	Switcher (Exp=1)	Exiter (Exp=0)	Exiter (Exp=1)	Non Exporters
Fixed investment/fixed capital (I/K)	11.94	15.15	11.71	9.99	7.43	5.65	9.28	8.23
Assets	1369.00	1147.00	1371.00	1083.00	738.50	856.10	1078.00	964.10
number of employees	564.20	304.10	422.20	278.20	342.20	289.20	367.50	216.40
wages	18.42	17.33	20.93	19.97	15.18	20.16	19.34	19.17
total factor productivity(tfp)	5.69	4.65	5.82	4.97	5.41	6.01	4.94	5.15
labour productivity	344.80	421.50	482.70	495.20	556.00	456.00	422.90	553.90
Financial Characteristics								
cash flow/fixed capital (CF/K)	39.06	42.02	47.40	43.28	46.46	48.38	47.16	44.06
liquidity	16.70	11.08	15.88	13.70	15.38	16.84	15.51	13.62
leverage	46.37	49.32	48.39	48.50	48.44	48.53	47.91	49.30
colleateral	32.17	36.19	30.67	33.43	31.92	28.94	31.33	33.60
Working capital-related variables								
Investment in working capital (IWK/K)	13.05	20.98	18.60	17.61	13.21	8.87	8.01	15.14
Working capital/fixed capital (WK/K)	116.13	90.15	128.57	110.35	104.33	118.71	115.80	126.68
Observations	37694	1678	3643	3731	2105	1492	5814	8348

Notes: See notes in table 3.2

Table 3.3 Descriptive statistics for firms by different ownership (continued)

	Collective							
General Characteristics	Continuous Exporters	New (Exp=0)	New (Exp=1)	Switcher (Exp=0)	Switcher (Exp=1)	Exiter (Exp=0)	Exiter (Exp=1)	Non Exporters
Fixed investment/fixed capital (I/K)	10.57	14.57	13.63	9.13	10.36	4.67	3.77	9.49
Assets	856.10	631.90	835.30	490.90	620.50	595.50	526.10	318.60
number of employees	544.50	369.40	361.80	348.90	371.10	289.50	294.20	228.30
wages	11.43	9.62	14.46	10.56	11.92	12.41	9.54	11.09
total factor productivity(tfp)	5.56	4.43	5.56	4.82	5.05	5.85	5.09	4.82
labour productivity	238.00	171.30	316.50	252.40	302.80	371.90	298.80	265.90
Financial Characteristics								
cash flow/fixed capital (CF/K)	45.05	31.58	37.95	43.37	57.16	44.10	33.82	43.28
liquidity	3.20	8.39	5.93	8.74	5.88	3.10	2.18	6.87
leverage	64.47	62.19	62.18	59.70	62.63	62.74	64.10	61.13
colleateral	30.92	31.70	31.14	33.28	32.26	31.68	33.52	33.58
Working capital-related variables								
Investment in working capital (IWK/K)	6.35	13.60	8.43	8.35	9.71	11.14	4.69	11.20
Working capital/fixed capital (WK/K)	49.35	76.52	64.71	68.45	61.19	59.40	35.01	47.18
Observations	2356	332	369	1919	1037	840	657	20646

Notes: See notes in table 3.2

3.4 Some stylized facts on financial constraint and working capital management of Chinese firms

From the discussion of the literature in section 3.2 and descriptive statistics in section 3.3, we can find that the firms in our sample are generally in a poor financial condition, implying that they may constrained by the liquidity to some extent. At the same time, it is noticed that the majority of our sample firms hold a high level of working capital. Hence, according to Ding et al. (2013), these firms may employ working capital as one possible source of funding in order to mitigate the liquidity shock. In this section, we will employ two neoclassic models to provide some stylized facts on whether the sample firms are in financial constraint or not, and whether the working capital can be used as a source of fund in the presence of the fluctuations of cash flow.

3.4.1 Neoclassic model for measuring financial constraints

Following Fazzari et al. (1988), Fazzari and Peterson (1993) and Ding et al., (2013), we set the estimation model for a firm's level of financial constraint as the following type:

$$I_{it}/K_{it} = \alpha_0 + \alpha_1(CF_{it} \,/\, K_{it}) + v_i + v_t + v_{jt} + e_{jt} \qquad (3.1)$$

Where:

I_{it} is firm i's investment at time t, K_{it}, is the fixed capital stock, and CF_{it} is refer to firm i's cash flow at time t. Hence, the dependent variable $I_{it} \,/\, K_{it}$ can be expressed as the capital investment ratio, while the independent variable $CF_{it} \,/\, K_{it}$ is usually denoted as the cash-flow ratio. In the financial constraint literature, the coefficient of $CF_{it} \,/\, K_{it}$ is usually interpreted as the cash-flow sensitivity to the investment. High cash-flow sensitivity to investment usually implies the firm is constrained by the liquidity (Fazzari et al., 1988). Hence, in the equation (3.1), α_1 is the indicator of the constraint level of the firms. The error term in equation (3.1) comprises a firm-specific time-invariant component (v_i), including all time-invariant firm characteristics likely to influence fixed investment, as well as the time-invariant component of the measurement error affecting any of the regression variables; a time-specific component (v_t) accounting for possible business cycle effects; an industry-specific time-specific component (v_{jt}), which accounts for industry-specific business cycle effects; and an idiosyncratic component (e_{jt}). We control for the firm-specific time-invariant component of the error term by estimating our equation in first-differences, for the time-specific component by including time dummies in all our specifications, and for the industry-specific time-specific component by including time dummies interacted with industry dummies.

In the previous literature, Tobin's Q is usually employed as the control variable of a firm's investment opportunities (Fazzari et al., 1988). However, firms in our sample are not listed on the stock market, implying that the Q cannot be calculated. Hence, following the previous research (Brown et al., 2009; Guariglia et al., 2011 and Ding et al., 2013), we can generate an alternative Q variable by including time dummies interacted with industry dummies (v_{jt}). This method can be regarded as an indirect way of accounting for investment opportunities, or more general demand factors, because the dummies account for all time-varying demand shocks at the industry level.

3.4.2 Neoclassic model for measuring working capital management

Following Fazzari and Peterson (1993) and Ding et al., (2013), once firms are constrained by the liquidity, they may seek help from working capital since it is typically characterized by lower adjustment costs than fixed capital investment (Carpenter et al., 1994), firms should find it easier and cheaper to adjust the latter instead of the former when cash flow fluctuation occurs. To test whether this is the case, we next estimate an equation of investment in working capital (IWK_{it}) as a function of cash flow. The equation is in the following form:

$$IWK_{it} \,/\, K_{it} = \beta_0 + \beta_1(CF_{it} \,/\, K_{it}) + v_i + v_t + v_{jt} + e_{it} \tag{3.2}$$

For the economic insights, β_1 displays the working capital management ability for the firms. The value of β_1 in equation (3-2) should be larger than the value of α_1 in equation (3-1). This expectation implies firms can partially offset the effects of negative cash flow shocks on their fixed investment by drawing down their stock of working capital. Similarly, during periods characterized by positive cash flow shocks, they could rebuild their working capital stock in anticipation of future negative cash flow shocks.

3.4.3 Estimation Methods

In terms of the estimation method for the two neoclassical models, the Ordinary Least Square (OLS) is not the best estimation method. First, our samples are from an unbalanced panel with a large number of N but small T, indicating that we need to take in to account unobserved firm heterogeneity and possible endogeneity of the repressors. In that case, the OLS estimation may have a biased result. Therefore, we estimate our equations using a first-difference Generalized Method of Moments (GMM) approach (Arellano and Bond, 1991). 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 three main 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.

This method uses the first-differencing in order to control firm-specific, time-invariant effects (v_i). Lagged values of the regressors are employed as instruments to control for the possible endogeneity of regressors. To assess whether our instruments are appropriate and our model is correctly specified or not, we check whether the variables in our instrument set are uncorrelated with the error term in the relevant equation, making use of two tests. The first is the Hansen test (also known as J test) for overidentifying restrictions. Under the null of instrument validity, this test is asymptotically distributed as a chi-square with degrees of freedom equal to the number of instruments less the number of parameters. The second test is based on the serial correlation in the differenced residuals. We assess the presence of n^{th}-order serial correlation in the differenced residuals using the m(n) test, which is asymptotically distributed as a standard normal under the null of no n^{th}-order serial correlation of the differenced residuals. 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 deeper. The latter instruments are valid in the absence of serial correlation of order n+1 in the differenced residuals (Brown et al., 2009). We initially used our regressors lagged twice as instruments. Since the Hansen test and/or the test for second order autocorrelation of the differenced residuals systematically failed, we lagged all our instruments three times. In all the tables, we therefore report the test for third order autocorrelation of the differenced residuals.

3.4.4 Empirical results

We initially estimate equation (3.1) for our four ownership groups. The results are reported in Table 3.4. In line with the literature (Ponect et al., 2010; Guariglia et al., 2011; Ding et al., 2013), all the coefficient related to the state-owned firms are insignificant. This indicates the capital investment ratio is not sensitive to the cash flow for both exporters and non-exporters in SOEs. This situation can be explained that the SOE is easily to obtain external finance from banks with favorable interest rates or the benefit from soft budget constraints (Bai et al., 2006).

For the other three groups, the coefficients are at least significant at 5% level. Hence, prior to analysis the results among the different groups, it is necessary to interpret the economic insights from the point estimation results. For example, the value of coefficient of successful private exporters is 0.375. In the equation (3.1), the dependent variable I/K is firm's investment ratio while the dependent variable CF/K is the cash-flow ratio. Hence, the value of 0.375 can be inferred as firm's investment ratio will increase (decrease) 0.375% when firm's cash-flow ratio goes upward (downward) 1%. Obviously, higher value of this coefficient indicates a stronger connection between firm's investment and cash-flow and firm's investment plan will be more affected by the liquidity shock. Therefore, a higher investment cash flow coefficient can be regarded as the firm is more likely to be financially constrained.

The results in other three firms indicate that both exporters and non-exporters are constrained by liquidity. The samples in private groups exhibit the highest investment cash flow sensitivity, which is in accordance with the previous studies (Guariglia et al., 2011 and Ding et al., 2013). This can be explained as the private firms are very hard to obtain loans from the state-owned banks (Allen et al., 2005). Foreign firms exhibit the lowest constraint and this should be their good financial condition shown in table 3.2.

For the different level of coefficients among different categories of exporters and non-exporters, it can be clearly seen that in all the three ownership groups, the level of financial constraint shows an increasing tendency from the successful exporters to the exit exporters. The fact that successful exporters face the lowest level of financial constraint is both in line with the features shown in the summary statistics and the finding in Greenaway et al. (2007).

The estimation results of equation (3.2) for our four ownership groups are shown in Table 3.5. Similarly with the investment-cash flow sensitivities, the investment working capital to cash flow ratio is not significant to the SOEs. For the remaining groups, except for the exit exporters, cash flow strongly affects working capital investment. The private firms exhibit the highest value of coefficients, which is in accordance with the results in table 3.4. i.e. the private firms face the most severe liquidity constraint, and they are more willing to use the working capital investment to alleviate the cash flow shocks.

The economic insights for the point of estimation are also similar to the investment-cash flow sensitivities. For instance, the estimated coefficient of successful private exporters is 0.497, indicating that the once the cash-flow ratio changes by 1%, the working capital investment ratio will change by around 0.5%. This coefficient is dramatically higher than that in the fixed investment regressions (0.375 for successful private exporters), which can be explained by the lower adjustment cost of working capital than fixed capital.

Compared the coefficients between export and non-export observations, we can find that the successful exporters exhibit the lowest sensitivities. If we analyze these results in conjunction with the corresponding coefficients in table 3.4, it can be explained as the successful exporters having relatively better financial health than other categories. When we compare the results in table 3.4 and 3.5 for the new exporters and switchers, we can find that the new exporters exhibit lower investment-cash flow sensitivity but higher working capital investment sensitivity than the switchers in the same ownership groups. This implies that, compared with the switchers, the new exporters are more willing to use the working capital to alleviate the liquidity shocks. In terms of the insignificant coefficient value in all the exiter columns, this can be explained in that these firms have a relative low level of the working capital, indicating that the margin value of working capital is relative high. Hence, the firms are not willing to adjust working capital in presence of the cash flow fluctuation (Ding et al., 2013).

To sum, in this section, we use two neoclassical models to show that all the non-SOE firms in our sample are constrained by the liquidity. In addition, some of the firms have high working capital sensitivities, implying that they may use working capital to migrate the cash flow shocks. Hence, it is possible that these firms may also use the working capital to overcome the sunk cost in order to make exportation. i.e. the working capital investment may have positive effect on firm's export decision. In order to investigate this question, we will use a probit model to test the relationship between export and working capital investment in the section 3.5 and 3.6.

Table 3.4 Neoclassical model for measuring investment-cash flow sensitivities

Dependent Variable: I/K	State Owned					Private				
	Successful	New	Switcher	Exiter	Non-exporter	Successful	New	Switcher	Exiter	Non-exporter
CF/K	0.132	-0.157	0.083	-0.065	0.103	0.375**	0.408***	0.411***	0.493***	0.382***
	(0.325)	(0.551)	(0.336)	(0.518)	(0.588)	(0.148)	(0.061)	(0.000)	(0.005)	(0.032)
J (p-value)	0	0.243	0	0.354	0.033	0.022	0.154	0.008	0.115	0.576
m1	0	0	0.03	0	0	0.01	0	0	0	0
m3	0.312	0.926	0.125	0.083	0.125	0.236	0.395	0.316	0.101	0.113
Observations	2801	1124	2231	1242	16703	28587	11638	20370	8064	83590

Note: All specifications were estimated using a GMM first-difference specification. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroscedasticity. Instruments in the three columns are $(CF/K)_{i(t-3)}$, plus time dummies and time dummies interacted with industry dummies. The J statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument validity. m1 is a test for first-order serial correlation in the first-differenced residuals, asymptotically distributed as N (0,1) under the null of no serial correlation. m3 is a test for third-order serial correlation in the first-differenced residuals, asymptotically distributed as N (0,1) under the null of no serial correlation.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level

Table 3.4 Neoclassical model for measuring investment-cash flow sensitivities (Continued)

Dependent Variable: I/K	Foreign					Collective				
	Successful	New	Switcher	Exiter	Non-exporter	Successful	New	Switcher	Exiter	Non-exporter
CF/K	0.186***	0.245***	0.263***	0.297***	0.236**	0.246***	0.306***	0.313***	0.367***	0.275***
	(0.003)	(0.032)	(0.030)	(0.005)	(0.098)	(0.052)	(0.083)	(0.004)	(0.015)	(0.103)
J (p-value)	0.016	0.784	0.512	0.327	0.532	0.312	0	0.294	0.257	0.637
m1	0	0	0	0.031	0	0	0	0	0.016	0
m3	0.543	0.474	0.103	0.088	0.107	0.354	0.513	0.105	0.099	0.371
Observations	37693	5321	9545	3597	8348	2856	701	2956	1497	20646

Note: All specifications were estimated using a GMM first-difference specification. The figures reported in parentheses are asymptotic standard errors. Time dummies and time dummies interacted with industry dummies were included in all specifications. Standard errors and test statistics are asymptotically robust to heteroscedasticity. Instruments in the three columns are $(CF/K)_{i(t-3)}$, plus time dummies and time dummies interacted with industry dummies. The J statistic is a test of the overidentifying restrictions, distributed as chi-square under the null of instrument validity. m1 is a test for first-order serial correlation in the first-differenced residuals, asymptotically distributed as N (0,1) under the null of no serial correlation. m3 is a test for third-order serial correlation in the first-differenced residuals, asymptotically distributed as N (0,1) under the null of no serial correlation.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level

Table 3.5 Neoclassical model for measuring working capital investment sensitivities

Dependent Variable: IWK/K	StateOwned					Private				
	Successful	New	Switcher	Exiter	Non-exporter	Successful	New	Switcher	Exiter	Non-exporter
CF/K	0.135	-0.157	0.091	-0.033	0.133	0.497**	0.638**	0.443*	0.214	0.519***
	(0.325)	(0.551)	(0.412)	(0.386)	(0.563)	(0.140)	(0.136)	(0.268)	(0.211)	(0.145)
J (p-value)	0.216	0.314	0.268	0.088	0.113	0.162	0.078	0.135	0.128	0.576
m1	0	0	0	0	0	0	0	0	0	0
m3	0.216	0.716	0.098	0.103	0.222	0.524	0.747	0.243	0.341	0.113
Observations	2801	1124	2231	1242	16703	28587	11638	20370	8064	83590

Note: see notes in Table 3.4.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

Table 3.5 Neoclassical model for measuring working capital investment sensitivities (Continued)

Dependent Variable: IWK/K	Foreign					Collective				
	Successful	New	Switcher	Exiter	Non-exporter	Successful	New	Switcher	Exiter	Non-exporter
CF/K	0.291**	0.477***	0.366***	0.237	0.387***	0.365***	0.508***	0.397***	0.221	0.386***
	(0.141)	(0.032)	(0.022)	(0.205)	(0.018)	(0.036)	(0.083)	(0.001)	(0.152)	(0.103)
J (p-value)	0.512	0.659	0.481	0.355	0.532	0.659	0.113	0.522	0.298	0.336
m1	0	0	0	0	0	0	0	0	0	0
m3	0.103	0.235	0.211	0.159	0.107	0.324	0.142	0.147	0.074	0.517
Observations	37693	5321	9545	3597	8348	2856	701	2956	1497	20646

Note: see notes in Table 3.4.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

3.5 Model specification and estimation method

In this part, we will employ a pool probit model, containing working capital investment ratio and a vector of firm characteristics which may affect firms' export decisions, to investigate the relationship between firm's export activity and the working capital investment. The hypotheses will be introduced as well.

3.5.1 Baseline models and estimation Methods

In this chapter, the dependent variable $EXPORT_{it}$ is a binary variable, and this kind of model is called the binary response model. For this model, our interest is primarily in the response probability for the model below:

$$p(Z) \equiv P(EXPORT = 1|Z) = P\left(y = 1\middle|Z_1, Z_{2,} \dots, Z_k\right) \tag{3.3}$$

Where p stands for outcome probability; Z is a vector of firm characteristics including working capital investment ratio. If we set this equation as a linear probability model and it is estimated by the OLS, the result will usually have two deficiencies: firstly, the fitted response probability may be below 0 or above 1, which is hard to interpret well. Secondly, the marginal effects for each independent variable are the same. Hence, we can use the pooled probit model to overcome these two shortcomings. The response probability of the probit model can be written as:

$$p\left(Z_{i(t-1)}\right) \equiv P\left(EXPORT_{it} = 1\middle|Z_{i(t-1)}\right) = \Phi(\gamma' Z_{i(t-1)}) \tag{3.4}$$

Where $\Phi(\cdot)$ denotes a normal cumulative distribution function of the error term which is assumed to lie between the range of 0 and 1, 0 < $\Phi(\cdot)$ < 1.

In terms of the baseline model, we identify those factors that are regarded as affecting a firm's export decisions, building from the existing theoretical and empirical literature for both developed and developing countries. Differences in firms' characteristics determine the individual performance and the capacity of a firm to export. The model we test specifies the relationship between the export decision and various factors. All independent variables are lagged by one year to control for potential endogeneity problems whereby previous characteristics of the firm determine the export decisions in the current period. Hence, the model is formed as follows:

$$P\left(EXPORT_{it} = 1 \middle| Z_{i(t-1)}\right) = \Phi\big[\gamma_0 \ + \gamma_1 IWK/K_{i(t-1)} + \gamma_2 EXPORT_{i(t-1)} + \gamma_3 size_{i(t-1)} + \gamma_4 wage_{i(t-1)} + \gamma_5 Prod_{i(t-1)} + v_j + v_t + e_{it}\big] \qquad (3.5)$$

Where:

$EXPORT_{it}$ is a dummy variable. It is equal to 1 when the firm i has an export record in year t and equals 0 if no export occurs.

$IWK/K_{i(t-1)}$ is the lagged working capital investment ratio for firm i in year t-1. The coefficient γ_1 is expected to be positive, implying that investing in working capital will contribute to the export activity. The positive sign can be explained if the firm has more working capital, the margin value of working capital will be lower and the firm is more willing to use it to make adjustment in the presence of liquidity shocks (Fazzari et al., 1993; Carpenter et al., 1994; Ding et al., 2013).

$EXPORT_{i(t-1)}$ is a lagged dependent variable. According to Cole et al. (2008 and 2010), this lagged dummy variable not only represents the sunk entry costs but also captures the previous export experience of the firm. Hence, the expected sign is positive since the firm will benefit from the paid sunk cost and the past experience.

$size_{i(t-1)}$ is the firm i's size in the year t-1, which we measure by two ways: the first way is the log of the firm's assets, and the alternative way is the log of employee number. Previous studies indicate the size can significantly affect the firm's export decisions (for example, see Bernard & Jenson, 1999; Farinas & Martin-Marcos, 2007; Greenaway & Kneller, 2007; Marinov et al., 2008). In the literature, both the total assets and the employees are used as the proxy of size. Hence, we will use the assets to make the baseline regression while the employees will be used in the robustness check. The expected sign is positive since the potential exporters are usually larger than the non-export counterparts.

$wage_{i(t-1)}$ is measured by the log of wages per employee and is an indicator of labour quality. This is also referred to in the literature (e.g. see Bernard & Jenson, 1999, Greenaway and Kneller, 2004). The expected sign is positive due to the exporters usually paying a higher salary than the non-export firms.

$Prod_{i(t-1)}$ is firm's level of productivity, which we also calculate in two ways: the first way is the firm's TFP, following the Levinsohn and Petrin (2003) method; and the second way is using the labour productivity, which is measured by the log of the labour productivity in the summary statistics. A large quantity of previous studies (e.g. see Melitz, 2003 for theoretical explanation while the empirical results can be found from Bernard & Jenson, 1999; Greenaway & Kneller, 2004; López, 2005; Farinas & Martin-Marcos, 2007) show that the exporters exhibit a higher level of productivity than the non-exporters. So the expected sign is positive as good firms will become indicators. In addition, the TFP will be employed in the baseline regression while the labour productivity will be used in the robustness test.

v_j denotes the industry component and v_t denotes time-specific component. We add these two variables to control the unobserved industry fixed effects and business cycle effects.

The baseline model (3.5) can be used to test the Hypothesis 3.1 and 3.2. In order to examine the hypothesis 3.3, we estimate following equation can be expressed as follows:

$$P\left(EXPORT_{it} = 1 \middle| Z_{i(t-1)}\right) = \Phi\left[\gamma_0 + \gamma_1 IWK/K_{i(t-1)} \times SOE + \gamma_2 IWK/K_{i(t-1)} \times PRIV + \gamma_3 IWK/K_{i(t-1)} \times FOR + \gamma_4 IWK/K_{i(t-1)} \times COL + \gamma_5 EXPORT_{i(t-1)} + \gamma_6 size_{i(t-1)} + \gamma_7 wage_{i(t-1)} + \gamma_8 Prod_{i(t-1)} + v_j + v_t + e_{it}\right] \quad (3.6)$$

In equation 3.6, The interaction term, SOE, PRIV, FOR, COL, represent the ownership of state-owned, private, foreign and collective, respectively. All the four variables are set as binary dummies. For example, in the observations of private firms, the PRIV is equal to one, while the others are zero.

In order to examine the hypothesis 3.4, we estimate following equation can be expressed as below:

$$P(EXPORT_{it}=1|Z_{i(t-1)}) = \Phi[\gamma_0 + \gamma_{11} IWK/K_{i(t-1)} \times HIGHWK + \gamma_{12} IWK/K_{i(t-1)} \times LOWWK + \gamma_2 EXPORT_{i(t-1)} + \gamma_3 size_{i(t-1)} + \gamma_4 wage_{i(t-1)} + \gamma_5 Prod_{i(t-1)} + v_j + v_t + e_{it}] \quad (3.7)$$

Where HIGHWK (LOWWK) is initially defined as a dummy variable equal to 1 if firm i's working capital to fixed capital ratio at time t is in the top (bottom) half of the distribution of the working capital of all firms operating in the same industry as firm i at time t-1, and 0 otherwise. We construct the HIGHWK and LOWWK variables for each of four ownerships separately.

3.5.2 Interpretation of the result from the probit model: marginal effects

In our estimated results, the coefficients obtained from the pooled probit estimation are the predicted probabilities of belonging to one of the categories. We compute the partial derivatives of probability with respect to each independent variable $Z_{ki(t-1)}$, which is known as marginal effects. Marginal effects indicate the slope of the expected change in the probability of the outcome when the independent variables are changed one at a time. A specific independent variable's marginal effect can be calculated at the mean of a particular variable keeping all other variables constant. The marginal effect of the pooled probit model can be given by:

$$\frac{\partial[P(EXPORT_{it}=1|Z_{i(t-1)})]}{\partial Z_{ki(t-1)}} = \frac{\partial[E(EXPORT_{it})]}{\partial Z_{ki(t-1)}} = \frac{\partial[\Phi(\gamma' Z_{i(t-1)})]}{\partial Z_{ki(t-1)}} = \Phi(\gamma' Z_{i(t-1)})\gamma_k \quad (3.8)$$

Where Φ is the probability density function for a standard normal variables; and Z_k is a coefficient of a particular continuous variable from the probit model where k=1, 2, 3,.., n.

3.5.3 Robustness check

In order to improve the robustness of the results from the baseline model above, we employ two methods for the robustness check.

First, we replace the proxy of two control variables: size and the productivity. For the size factor, we change the proxy from firm's assets to the number of employees. With respect to the productivity, we change the proxy from TFP, calculated by the method of Levinsohn and Petrin (2003), to the labour productivity. We also transfer these two variables from the original value to the log value in order to make the interpretation easily and consistently.

Second, we consider the potential endogeneity, because the potential reversed causation may lead to simultaneity bias (Roberts & Whited, 2012). For instance, the increment of working capital investment may improve the possibility of firms' export decisions. However, exporters may expand the investment in working capital in order to enlarge production. Another case is the relationship between export decisions and firm size. Previous studies find that firms with higher size are more likely to be exporters. Nevertheless, if the firms can export continuously, they often expand the firm size. Therefore, we employ the Instrumental Variable (IV) approach to test our baseline model specification. According to Ding et al. (2012) and Roberts and Whited (2012), except for the $EXPORT_{i(t-1)}$,we instrument all the right-hand-side variables using their own values lagged twice (i.e. $Z_{i(t-2)}$). The validity of the instruments can be discussed as follows: firstly, the IV ($Z_{i(t-2)}$) we employed is related to the endogenous variables $Z_{i(t-1)}$, as the value of variable in the previous period has impact on that of the current period (Wooldridge, 2002). Secondly, the IV ($Z_{i(t-2)}$) we used cannot directly impact the dependent variable ($EXPORT_{it}$) but only impact $EXPORT_{it}$ through the effects on the endogenous variable $Z_{i(t-1)}$. This implies that the IV we used satisfies the exclusion condition. Hence, we will use this IV method to examine our baseline model (3.5) and ownership model (3.6).

3.6 Empirical results

3.6.1 Pooled probit model for firm's export decision including heterogeneity

3.6.1.1 Results for the entire sample

In this part, we will first run the equation (3.5) for the entire samples. However, for the successful export and non-export samples, the dependent variable in every observation is in the same value (i.e. the values of $EXPORT_{it}$ are all 1 in the successful sample and 0 in the non-export sample). In this case, the probit model cannot predict the export possibility. Hence, in this part, we will initially divide the sample into two parts: "continuous exporters" and "switchers, exiters and non-exporters". The former sample contains the successful exporters and new exporters, while the latter sample includes switchers, exiters and non-exporters. Then we will estimate these two samples and report the corresponding marginal effects.

The estimation results of equation (3.5) for the entire samples can be seen in table 3.6. For the continuous exporters, the marginal effect of the working capital investment ratio is significant. To be more specific, the economic insight for the marginal effect of $IWK/K_{i(t-1)}$ for continuous exporter sample is 0.0213, indicating that once the investment in working capital increases by 1% in the year t-1, the export probability of the private new exporter will increase by 2.13% in the year t. This result is not hard to understand since firms will have more working capital for adjustment in the presence of the liquidity shock once they invest more in the working capital (Ding et al., 2013). The marginal effects of IWK/K in the other two samples are poorly determined. This is reasonable since these two samples contain a large number of the non-export firms, which may lead the coefficients to be insignificant.

Prior to comparing the coefficient values from different samples, we had run a seeming unrelated regression (SUR) following Davidson and Mackinnon (1993) to test whether the coefficients obtained from different samples were the same. The estimation results can be interpreted as follows: the p-values in the table 3.6 are all smaller than 0.05, indicating that the null hypothesis of the SUR is rejected at 5% significant level. So the values of coefficients from the three samples can be regarded as different at least at the 5%

level.

In terms of other firm heterogeneity, the results show that the past experience of a firm or sunk entry costs (*EXPORT* $_{i(t-1)}$) has the largest effect on the firm's export decision. This result is in line with previous literature (e.g. Cole et al., 2008 and 2010). T sunk cost has the largest effect on the continuous exporters: the export experience in the previous period increases the probability of the current exporting by 70.5%. For the full samples, the sunk cost has a lower effect on the export decision (51.1%). This effect is even lower in the switchers, exiters and the non-exporter sample (42.6%). Regarding the size factor, only the coefficient in the continuous exporter sample is determined at 10% confidence level, and the coefficient can be interpreted as an increase in firm's total asset of 1% raising the probability of exporting by 1.13%. This phenomenon is in line with previous studies (e.g. Greenaway et al., 2007, Cole et al., 2008 and Cole et al., 2010). However, these previous studies use dummy variables to determine the level of size. So we cannot compare the results directly. For the wage factor, all the reported coefficients are insignificant. In terms of the productivity, the coefficients are all positively and significantly determined. The corresponding coefficients in column (1) to (3) can be explained as follows: when the TFP increases by 1 unit, the probability of exporting will be raised by 3.08%, 3.32% and 2.76%, respectively. This result is in accordance with both the theoretical studies (e.g. Melitz, 2003) and empirical studies (see Lopez, 2005; Farinas & Martin-Marcos, 2007) on the relationship between firm-level productivity and export decision.

3.6.1.2 Results for different status of exporters

In this part, we run the regression equation (3.5) using only the export samples. To be more specific, we divide the exporters to four groups: continuous exporters (including successful and new exporters), new exporters, switch exporters and exit exporters. The estimation results can be found in table 3.7.

For the working capital investment factor, the continuous exporters (i.e. column (4) and (5)) show a higher level of positive effect on export decision than the two non-continuous exporters (i.e. column (6) and (7)). Specifically, IWK/K in the new exporters exhibits the highest partial effect on the export (2.71%), higher than the effect in column (4) (2.13%), indicating that new exporters are relatively more reliant on using working capital during the export. For the switchers, the lower value of the IWK/K effect (1.42%) can be explained in that, compared with the new exporters, they have a lower level in both the working capital investment and working capital stock (see table 3.2). This can also partially explain the insignificant IWK/K value in exiters: the exiters have the lowest level of working capital among these groups.

In terms of the sunk entry cost effect, the coefficients are all positive but they descend from the column (4) to column (7). This can be interpreted as the importance of the previous export experience decreasing from the most successful exporters to the least successful exporters. For the size effects, the marginal effect is only significant at the 10% level on the continuous and new exporters, but not significant for the switchers and exiters. The estimated marginal effects show that, for the continuous and new exporters, the 1% increase in a firm's assets will induce the increment of export probability by 1.27% and 1.13%, respectively. From the summary statistics (table 3.2), we can find that the successful and new exporters are usually larger than the switch and exit export firms. Hence, this is also in keeping with the relevant literature (Greenaway et al., 2007 and Cole et al., 2010), pointing out that the size effect is usually significant in the relevant larger firms, but not in the smaller firms. For the wage factor, all the reported coefficients are insignificant again. Regarding the productivity, the values of the coefficient in columns show again that the productivity is a positive and significant determinant of the decision to export. The increase of 1 unit of TFP will raise the probability of exporting from 2.7% to 3.6%. Similarly to the value of size, the switchers and exiters show a lower effect than those in the continuous and new exporters. Hence, for the explanation of why the switchers and the exiters cannot be continuous exporters, when we combine the estimation results and the facts deduced from the summary statistics and stylized facts, we can infer two possible reasons. Firstly, compared with the successful and new exporters, the switchers and exiters do not hold a high level of working capital, so they may not be willing to use working capital as a possible source of funding (Fazzari and Petersen, 1993; Ding et al., 2013). Secondly, compared with the successful and new exporters, the switchers and exiters usually show lower investment level, small size, less salary payments and lower productivity and more severe level of financial constraints. These facts indicates the switch and exit firms have a worse performance than the continuous export firms, and this is consistent with the relevant literature (see Aw et al., 2000; Bernard & Jensen, 2007; Harris & Li, 2011).

3.6.1.3 Results for different status of exporters with different ownerships

In this part, we further refine the sample by adding the different ownerships. The results for the equation (3.6) can be seen in table 3.8.

First, similar with the relevant literature focusing on Chinese firm-level studies (Guariglia et al., 2011; Ding et al., 2013 and Chen & Guariglia, 2013), the SOEs are still the unique group since, among all the groups of exporters, they only show positive and significant marginal effects in productivity. The working capital investment, sunk entry costs and size cannot determine their decision to export. This can be explained in that SOEs in China are organizations with multiple goals, not only chasing profit. Hence, the SOE can be benefit from soft budget constraint (Bai et al., 2006).

For the other three ownership firms, except for the exiters, all other exporter groups show that IWK/K has a positive and significant effect on the export decision and the overall trend in each ownership is also in line with the trend shown in table 3.7: the new exporters show the largest IWK/K effect, while the continuous exporters have higher effects than those of the switchers. Specifically, for the new exporters, one percent increment on working capital investment can raise the export probability from 2.2% to 3.3% depending on the different firm ownership. However, the same increment of IWK/K in switchers can only increase the export probability from 1.3% to 1.7%. In every export group, the private firms exhibit highest IWK/K marginal effect while the foreign firms show the lowest effect. This is because the private exporters are the most constrained ones while the foreign exporters are the least constrained ones, which is shown in the stylized facts and is also in line with the relevant studies (Ding et al., 2013 and Guariglia et al., 2011). For the controlled factors, the overall trend is in line with what have reported in the table 3.7. Although the coefficients cannot be directly compared, the values of control variable in table 3.7 and 3.8 are very similar. Therefore, we will not make further interpretation regarding the value of the other controlled variables.

3.6.1.4 Robustness check

3.6.1.4.1 Changing proxies of the control variables

Table 3.9 reports the results for the exporters without taking into consideration the ownership. Compared with the results shown in table 3.7, it can be seen that our robustness check is generally consistent with the original result. Specifically, for the working capital investment effect, the new exporters still show the largest effect (1% increase in IWK/K will raise the export probability by 2.72%), while the effect in continuous exporters (2.09%) is higher than that in the switchers (1.44%). The IWK/K effect for the exiters is still poorly determined. The effects from sunk entry cost and past experience are also similar to the original result, successful export in the previous year can increase the export probability by a range from 51.3% (exiters) to 76.8% (continuous exporters). Size effects are still only positively and significantly determined in the continuous and new exporters, but the values (1.26% and 1.37% for continuous and new exporters, respectively) are slightly higher than using the proxy of assets (1.27% and 1.13% for continuous and new exporters, respectively). The productivity effects are also properly determined, and the values (ranged from 2.65% to 3.51%) are slightly lower than those using the TFP (from 2.73% to 3.66%).

Table 3.10 reports the results from samples with different export status and ownerships. For the IWK/K effects, the overall tendency is consistent with the original results shown in the table 3.8, and the corresponding marginal values in the two tables only change very slightly (less than 0.05%). In terms of the effects from previous export experience, the values in the continuous and switch exporters shown in table 3.10 are almost the same as the corresponding values displayed in table 3.8. For the new exporters, the effects are slightly raised in the robustness results. However, the overall trend is still consistent with the original results. Regarding the controlled variable, the changes in the overall trend are also in accordance with that in the table 3.9. Again, the values are very similar. Therefore, we will not make further explanation.

3.6.1.4.2 IV probit method for overcoming the reversed causation

Table 3.11 and 3.12 reports the results of the IV probit method. Overall, it can be said that results from the IV probit method are generally consistent with the results from the baseline model. Hence, there may not exist a simultaneous relationship between the export decision and the working capital investment. In other words, the only relationship here is that investing in working capital may lead to improving the probability of making an export decision.

For the table 3.11, the overall trend of working capital investment is the as same as that shown in table 3.7. New exporters still show the largest effect (1% increase in IWK/K will raise the export probability by 2.44%), while the effect in continuous exporters (1.87 %) is higher than that in the switchers (1.24%). The IWK/K effect for the exiters is still poorly determined. In terms of the $EXPORT_{i(t-1)}$, successful export in the previous year can increase the export probability by a range from 43.3% (exiters) to 71.1% (continuous exporters). Size effects are still only positively and significantly determined in the continuous and new exporters, and the values are 1.36% and 1.47%, respectively. The productivity effects are also properly determined, and the values range from 2.84% to 3.63%. Regarding the results in table 3.12, the overall tendency of IWK/K effect is consistent with the origin results shown in table 3.8. For the controlled variables, the tendency is in line with that in 3.8 and 3.11.

Table 3.6 Firm's export decision including heterogeneity: entire sample

Dependent Variable: *EXPORT*	Full Sample	Continuous Exporters	Switchers, exiters and non-exporters	
	(1)	(2)	(3)	p-value
$IWK/K_{i(t-1)}$	0.0135	0.0213***	0.0071	0.003
	(0.816)	(0.003)	(5.64)	
$EXPORT_{i(t-1)}$	0.511***	0.705***	0.426***	0.000
	(0.003)	(0.025)	(0.117)	
$size_{i(t-1)}$	0.0091	0.0113*	0.0085	0.014
	(1.122)	(0.006)	(0.007)	
$wage_{i(t-1)}$	0.0331	0.0364	0.0317	0.006
	(0.368)	(0.41)	(1.122)	
$Productivity_{i(t-1)}$	0.0308***	0.0332***	0.0276***	0.027
	(0.002)	(0.007)	(0.001)	
Observations	273341	94451	178890	

Notes: All specifications were estimated using pooled probit model specification. The predicted probabilities reported are marginal effects calculated as equation (3.7). The figures reported in parentheses are asymptotic standard errors. Time dummies and industry dummies were included in all specifications. Standard errors are adjusted for clustering at the two-digit industry level. $size_{i(t-1)}$ is the log fixed assets, $Productivity_{i(t-1)}$ is the TFP calculated by Levinsohn and Pertin (2003). All the independent variables are lagged one year. The p-value refers to a test of the null hypothesis that the marginal effects from different samples are equal.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

Table 3.7 Firm's export decision including heterogeneity: by different kinds of exporters

Dependent Variable: *EXPORT*	Continuous Exporters	New exporters	Switchers	Exiters	
	(4)	(5)	(6)	(7)	p-value
$IWK/K_{i(t-1)}$	0.0213***	0.0271***	0.0142**	0.0089	0.000
	(0.003)	(0.001)	(0.008)	(0.63)	
$EXPORT_{i(t-1)}$	0.767***	0.705***	0.539***	0.507***	0.000
	(0.025)	(0.016)	(0.117)	(0.118)	
$size_{i(t-1)}$	0.0127*	0.0113*	0.0103	0.0094	0.026
	(0.007)	(0.0065)	(0.811)	(0.028)	
$wage_{i(t-1)}$	0.0364	0.0352	0.0347	0.0245	0.033
	(0.41)	(0.48)	(1.105)	(0.429)	
$Productivity_{i(t-1)}$	0.0332***	0.0366***	0.0317***	0.0273***	0.014
	(0.007)	(0.006)	(0.001)	(0.001)	
Observations	94451	18784	35202	14400	

Notes: See notes to table 3.6.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

Table 3.8 Firm's export decision including heterogeneity: by different status of exporter and ownership

Dependent Variable: *EXPORT*	Continuous Exporters	New exporters	Switchers	Exiters	
	(8)	(9)	(10)	(11)	p-value
$IWK/K_{i(t-1)} \times SOE$	-0.0003	0.0016	0.0009	0.0004	0.056
	(3.56)	(5.64)	(0.188)	(0.714)	
$IWK/K_{i(t-1)} \times PRIV$	0.0222***	0.0331***	0.0172***	0.0097	0.000
	(0.003)	(0.002)	(0.004)	(0.125)	
$IWK/K_{i(t-1)} \times FOR$	0.0165**	0.0222***	0.0134***	0.0127	0.004
	(0.007)	(0.003)	(0.001)	(0.316)	
$IWK/K_{i(t-1)} \times COL$	0.0196***	0.0267***	0.0141**	0.0051	0.003
	(0.004)	(0.005)	(0.007)	(0.384)	
$EXPORT_{i(t-1)}$	0.757***	0.715***	0.536***	0.508***	0.006
	(0.025)	(0.016)	(0.117)	(0.118)	
$size_{i(t-1)}$	0.0131*	0.0122*	0.0115	0.0096	0.022
	(0.007)	(0.0065)	(0.811)	(0.028)	
$wage_{i(t-1)}$	0.0361	0.0342	0.0337	0.0246	0.033
	(0.41)	(0.48)	(1.1032)	(0.433)	
$Productivity_{i(t-1)}$	0.0232***	0.0366***	0.0317***	0.0273***	0.014
	(0.007)	(0.006)	(0.001)	(0.001)	
Observations	94451	18784	35202	14400	

Notes: See notes to table 3.6

Table 3.9 Robustness check: by changing proxies of control variables

Dependent Variable: *EXPORT*	Continuous Exporters	New exporters	Switchers	Exiters	
	(12)	(13)	(14)	(15)	p-value
IWK/K $_{i(t-1)}$	0.0209***	0.0272***	0.0144**	0.0085	0.006
	(0.003)	(0.001)	(0.007)	(0.65)	
EXPORT $_{i(t-1)}$	0.768***	0.711***	0.538***	0.513***	0.000
	(0.025)	(0.016)	(0.117)	(0.118)	
size $_{i(t-1)}$	0.0126*	0.0137*	0.0091	0.0083	0.066
	(0.007)	(0.007)	(0.926)	(0.134)	
wage $_{i(t-1)}$	0.0361	0.0355	0.0342	0.0245	0.071
	(0.39)	(0.44)	(1.213)	(0.427)	
Productivity $_{i(t-1)}$	0.0327***	0.0351***	0.0313***	0.0265***	0.019
	(0.002)	(0.000)	(0.001)	(0.001)	
Observations	94451	18784	35202	14400	

Notes: *size* $_{i(t-1)}$ is the log value of employee numbers, *Productivity* $_{i(t-1)}$ is the labour productivity. Also see notes to table 3.6.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

Table 3.10 Robustness check: by changing proxies of control variables and ownership

Dependent Variable: *EXPORT*	Continuous Exporters	New exporters	Switchers	Exiters	
	(16)	(17)	(18)	(19)	p-value
$IWK/K_{i(t-1)} \times SOE$	-0.0002	0.0015	0.0011	0.0089	0.102
	(3.51)	(6.11)	(0.188)	(0.63)	
$IWK/K_{i(t-1)} \times PRIV$	0.0187***	0.0333***	0.0143***	0.0097	0.000
	(0.002)	(0.002)	(0.004)	(0.125)	
$IWK/K_{i(t-1)} \times FOR$	0.0155**	0.0207***	0.0174***	0.0129	0.003
	(0.009)	(0.002)	(0.001)	(0.313)	
$IWK/K_{i(t-1)} \times COL$	0.0220***	0.0257***	0.0138**	0.0048	0.005
	(0.002)	(0.003)	(0.001)	(0.384)	
$EXPORT_{i(t-1)}$	0.767***	0.811***	0.638***	0.553***	0.000
	(0.025)	(0.016)	(0.117)	(0.118)	
$size_{i(t-1)}$	0.0133*	0.0138*	0.0093	0.0081	0.099
	(0.007)	(0.007)	(0.926)	(0.134)	
$wage_{i(t-1)}$	0.0354	0.0342	0.0336	0.0265	0.072
	(0.39)	(0.44)	(1.213)	(0.427)	
$Productivity_{i(t-1)}$	0.0303***	0.0381***	0.0322***	0.0267***	0.000
	(0.002)	(0.000)	(0.001)	(0.001)	
Observations	94451	18784	35202	14400	

Notes: $size_{i(t-1)}$ is the log value of employee numbers, $Productivity_{i(t-1)}$ is the labour productivity. Also see notes to table 3.6.

Table 3.11 Robustness check by IV Probit: different export status

Dependent Variable:*EXPORT*	Continuous Exporters	New exporters	Switchers	Exiters	
	(20)	(21)	(22)	(23)	p-value
IWK/K $_{i(t-1)}$	0.0187***	0.0244***	0.0124**	0.0069	0.006
	(0.004)	(0.002)	(0.007)	(0.71)	
EXPORT $_{i(t-1)}$	0.711***	0.645***	0.454***	0.433***	0.000
	(0.031)	(0.022)	(0.128)	(0.124)	
size $_{i(t-1)}$	0.0136*	0.0147*	0.0134	0.0154	0.066
	(0.011)	(0.008)	(0.295)	(0.185)	
wage $_{i(t-1)}$	0.0372	0.0415	0.0351	0.0268	0.071
	(0.44)	(0.512)	(1.336)	(0.567)	
Productivity $_{i(t-1)}$	0.0347***	0.0363***	0.0336***	0.0284***	0.019
	(0.003)	(0.002)	(0.002)	(0.002)	
p-value (Wald test)	0.000	0.000	0.000	0.000	
Observations	80945	16098	30168	12341	

Notes: Both the independent and the control variables are instrumented using their own values lagged twice. Also see notes to table 3.6.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

Table 3.12 Robustness check by IV Probit: different export status and ownership

Dependent Variable: *EXPORT*	Continuous Exporters	New exporters	Switchers	Exiters	
	(24)	(25)	(26)	(27)	p-value
$IWK/K_{i(t-1)} \times SOE$	-0.0003	0.0017	0.0014	0.0066	0.044
	(3.66)	(6.54)	(0.19)	(0.66)	
$IWK/K_{i(t-1)} \times PRIV$	0.0192***	0.0352***	0.0139***	0.0076	0.000
	(0.003)	(0.004)	(0.005)	(0.128)	
$IWK/K_{i(t-1)} \times FOR$	0.0177**	0.0234***	0.0155***	0.009	0.002
	(0.009)	(0.004)	(0.002)	(0.33)	
$IWK/K_{i(t-1)} \times COL$	0.0236***	0.0271***	0.0118**	0.0032	0.007
	(0.002)	(0.005)	(0.002)	(0.446)	
$EXPORT_{i(t-1)}$	0.689***	0.605***	0.423***	0.388***	0.000
	(0.031)	(0.022)	(0.128)	(0.124)	
$size_{i(t-1)}$	0.0123*	0.015*	0.0132	0.0152	0.068
	(0.011)	(0.008)	(0.331)	(0.185)	
$wage_{i(t-1)}$	0.0377	0.0404	0.0363	0.0278	0.071
	(0.44)	(0.512)	(1.336)	(0.567)	
$Productivity_{i(t-1)}$	0.0344***	0.0366***	0.0337***	0.0288***	0.019
	(0.003)	(0.002)	(0.002)	(0.002)	
p-value (Wald test)	0.000	0.000	0.000	0.000	
Observations	80945	16098	30168	12341	

Notes: *See* notes to table 3.6 and 3.11.

3.6.2 Do firms with different level of working capital have the same level of working capital investment management ability?

The estimation results of equation (3.7) for the four types of exporter are shown in table 3.13. In this estimation, we distinguish firms in the same industry by the level of working capital. For the other control variables, table 3.13 reports that the marginal effects are only changed very slightly from the results in the basic probit specification in section 3.6.1. Hence, we will not discuss these effects of the variables in this part, but only focus on analyzing the working capital investment effects.

From table 3.13, we can see that, for the firms with high level of working capitals, the overall trend of working capital effect is similar to the results shown in table 3.7: the new exporters show the highest level of effect (1% increment of working capital investment raises the export probability by 3.26%), and the effect among continuous exporters (2.95%) is higher than that in switchers (1.77%). The tendency among exporters with low level of working capital is similar to the high ones, but all the marginal effects are insignificant. According to Ding et al. (2013), this is because, for firms with a high level of working capital, the marginal value of working capital is relatively low, implying that working capital can be easily adjusted. Similarly, the firms with low level of working capital are unable or not willing to use their working capital to alleviate the liquidity constraint since the increment of their working capital has a high marginal value (Fazzari et al., 1993; Carpenter et al., 1994). This argument can also explain the insignificant values among exit exporters since these firms shows the lowest level of average working capital stock among the four types of exporters. Therefore, firms with relative high working capital in this group may still exhibit a relatively high marginal value on the working capital, which lead them to be unable or unwilling to adjust working capital in the presence of cash flow shock.

Table 3.13 Firm's export decision including heterogeneity: differentiating firms on the level of working capital

Dependent Variable: *EXPORT*	Continuous Exporters	New exporters	Switchers	Exiters	
	(28)	(29)	(30)	(31)	p-value
$IWK/K_{i(t-1)}* HIGHWK_{i(t-1)}$	0.0295***	0.0326***	0.0177**	0.0137	0.005
	(0.000)	(0.002)	(0.000)	(0.42)	
$IWK/K_{i(t-1)}*LOWWK_{i(t-1)}$	0.0169	0.0194	0.0812	0.0055	0.018
	(0.51)	(1.06)	(2.21)	(0.88)	
$EXPORT_{i(t-1)}$	0.766***	0.708***	0.541***	0.510***	0.001
	(0.023)	(0.015)	(0.115)	(0.123)	
$size_{i(t-1)}$	0.0123*	0.0114*	0.0102	0.0095	0.067
	(0.0071)	(0.0065)	(0.841)	(0.0267)	
$wage_{i(t-1)}$	0.0364	0.0352	0.0347	0.0245	0.052
	(0.41)	(0.48)	(1.105)	(0.429)	
$Productivity_{i(t-1)}$	0.0328***	0.0368***	0.0315***	0.0270***	0.032
	(0.007)	(0.000)	(0.001)	(0.001)	
Observations	94451	18784	35202	14400	

Notes: HIGHWK (LOWWK) is a dummy variable equals to 1 if firm i's working capital to fixed capital ratio at time t-1 is in the top (bottom) half of the distribution of the working capital of all firms operating in the same industry as firm i at the time t-1, and 0 otherwise. Also see notes to table 3.6.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

3.7 Conclusion

In this chapter, we have studied the relationship between export activities and working capital management for Chinese non-listed firms. Theoretically, we use a binary probit model to investigate how the working capital management can affect the probability of firm being an exporter. Empirically, we employ a panel of over 270,000 observations from 2000 to 2007 to find the linkage between the export and working capital sensitivities.

The results show that, firstly, among different status of the exporters, working capital investment shows the most significant contribution to the new exporters. Between the continuous exporters and the switch exporters, the contribution of working capital investment to the export decision is larger in the former. For the exit exporters, working capital effect is poorly determined, indicating that they cannot use their working capital to help them export. In addition, combining the summary statistics, stylized facts and the empirical result, we can also infer that the possible reason for the firms quitting the international market is their poor performance. Secondly, among different types of ownerships, only the SOEs are not working-capital investment sensitive. This is in line with previous research (Guariglia et al., 2011; Ding et al., 2013), which may due to the fact that the SOEs can benefit from the soft budget constraints (Bai et al., 2006). In terms of other three ownerships, the private firms show the largest working capital investment effect on their export decisions, while the foreign firms show the smallest effect since they are less financially constrained than private and collective firms. Thirdly, only firms with a relative high level of working capital can use working capital investment to promote their export activities, since the marginal value of working capital is relative high when the level of working capital stock is low. Finally, the results from the IV probit model prove that the relationship between working capital investment and export decision is one-sided.

The policy implications of the findings are that firms who are willing to be exporters need to improve their ability of working capital management. In terms of different status of exporters, this is crucially important for the switchers. The switchers show lower willingness to use working capital than the continuous exporters. This may be caused by the relatively low level of working capital stocks. However, another possible reason is that they cannot use the working capital as well as the continuous exporters. From the view of different ownerships, we find that the working capital investment is particularly important for the collective firms, which exhibit the lowest exporter ratio among all the ownership groups. Although the collective firms can be partially regarded as the state-owned, they seem not to benefit from the soft budget constraints. Hence, increasing the level of working capital management ability is a possible method to overcome the sunk costs and become exporters.

The limitations of this chapter are as follows. Firstly, we do not have the market data, indicating we cannot make comparisons between non-listed and listed firms. Secondly, due to the limit of the NBS database, some of the sub-samples are small (e.g. collective firms in the exporters group).

Chapter 4 - A stochastic frontier approach for the determinants of financial constraints for Chinese firms: does ownership and industry matters?

4.1 Introduction

Over the past decades, many studies have been devoted to providing evidence for a hypothesis of financing constraints on investment (see Fazzari et al. (1988) as an example). According to this hypothesis, capital market imperfection is due to the asymmetric information problem. In addition, the imperfect market also makes the corporate capital investment not only determined by the fundamental factors such as Tobin's Q, but also by financial factors (e.g. cash flow). Particularly, investment may be constrained if market imperfections impose difficulties for financing investment. Hence, in the empirical research, the model may be misspecified if we cannot consider the effect of financial constraint.

In the literature, it is usually difficult to specify the relationship by employing a structural model. For instance, in the Euler equation model (see Whited (1992) as an example), the main doubt is a structural model with a series of assumptions, and the null hypothesis may be rejected if any one of the assumptions is loosened (Coad, 2010). In addition, another common problem for this approach is the use of *ad hoc* classification criteria to separate firms into *a priori* constrained and unconstrained groups (Wang, 2003; Bhaumik et al., 2012). Hu and Schiantarelli (1998) also argue that the dependence on a single indicator to separate samples is risky since it is impossible that the firms' financial status does not change over time. In addition, the sample selection may also raise the probability of endogeneity problems.

In that case, some studies try to avoid using a single indicator to split the samples. The most common measurement is to combine several variables to generate an index. For instance, Whited and Wu (2006) proposed an index based on the Euler equation model in Whited (1992). However, the shortcomings of this method are similar to those in the structural model equations. Another example is that given by Musso and Schiavo (2008), which ranks firms in a certain class by industry or region. Rankings can be calculated upon a set of variables which may reflect firms' financial status. However, as this rank variable is of an ordinal nature, no one can guarantee that the differences between each two neighboring ranks are the same.

Based on the discussion above, it is clear to see that, in the stylized literature, there exist extensive measures to determine the financial constraints. However, they have some common disadvantages. Firstly, the above mentioned methods only provide marginal effect, but fail to provide a firm-specific and time-varying variable to directly measure the financial constraint. Secondly, some methods need to make *a priori* classification of samples, which may cause sample selection bias.

Therefore, in this chapter, following Wang (2003) and Bhaumik et al. (2012), we propose a new estimation strategy that overcomes some of the aforementioned problems. This method does not separate samples *a priori* to test investment cash flow sensitivity (ICFS). In addition, this method can provide not only cross-sectional, but also intertemporal comparisons of the financial constraint effects. In this chapter, we examine not only the ICFS, which is similar to the stylized literature, but also the investment efficiency among different firm characteristics. To be more specific, the contributions can lead to two conclusions. Firstly, rather than inferring the existence of financial constraint from the sign and significance of the cash flow variable, the stochastic frontier approach enables us to estimate a measure of financial constraint for each individual firm and at each point in time. Since our outcome variable (desired or optimum investment) has a natural unobserved maximum, the observed value of the outcome variable will never exceed its desired (maximum) value. We estimate the unobserved maximum value (desired investment) econometrically using actual data on the outcome variable and some covariates, and thereby compute the shortfall of investment from its desired value. This shortfall is then attributed to financial constraint. Secondly, we are able to directly estimate the marginal impact of firm characteristics such as size, leverage and coverage on financial constraint, without inferring the different degrees of financial constraint on different types of firms by splitting the sample into different groups based on any *ad hoc* criteria, and thereafter estimating the different degrees of responsiveness of the investment of the average firm in each of these groups to cash flows.

Other than using new methodology, another motivation for this research is the high growth in Chinese firms. According to Guariglia et al. (2011), Chinese firms have been growing very fast over the last decades. The average firm-level growth rate was 8.6% from 2000-2007. For the private firms, they grew rapidly after Deng Xiaoping's Southern Tour in 1992. In 2004, the private sector provided nearly a half of the total employment and 60% of the overall output (Li et al., 2008). The underline of the rapid growth should be large quantities of investment. However, the financial fundamental in China is a bank-based system (Allen et al., 2005), while this system is related to political and social issues (Li et al., 2008). The previous research (Guariglia et al., 2011; Ding et al., 2013) has proved that firms in private ownership have difficulty in accessing bank loans, while the SOEs are more likely to get them. In that case, the private firms should show higher investment efficiency than the SOE firms. Indeed, some literature (see Zhang (2003) as an example) examines the investment efficiency in China at an aggregate level and finds that the overall investment efficiency is increasing since 1978 while the private sectors show a higher efficiency than that in the industries controlled by the state. However, there is lack of evidence on the comparison of investment efficiency between state-owned sectors and private sectors at firm level. In this chapter, we can make a comparison between SOEs and private firms since the stochastic frontier model can generate an index to show investment efficiency for each firm in each observation year.

We use the stochastic frontier approach to estimate measures of financial constraints among a panel of 66,500 Chinese unlisted firms, for the 2000-2007 period and identify firm characteristics that explain variations in these measures across firms and over time. Our main findings are that, in accordance with the existing literature in firm-level investments, higher level of cash flows, assets and coverage ratio can alleviate financial constraints. The degree of financial constraint is higher for highly leveraged firms. These results are consistent with the literature investigating the ICFS regarding both the Chinese listed and private firms. We also make post estimations to determine whether ownerships, regions and the industries affect the firms' financial constraint status. For the entire samples, the investment efficiency distribution is roughly left-skewed, indicating that the majority of firms show a significant level of financial constraint. Regarding the different ownerships, private firms show the highest efficiency while the SOE firms show the lowest efficiency, which is also in keeping with the existing literature. However, the foreign firms show a lower efficiency than the private and collective firms. In terms of the marketization factor, firms in regions with high level of legal institution show higher efficiency. For the industry factors, we find that industries in the tertiary sector show a relative higher efficiency than industries in the secondary sector. However, the secondary sectors show a more stable efficiency across years. Finally, some industries in the tertiary sector display a different tendency of financial constraint, which may be affected by the firm ownership.

The remainder of this chapter is organized as follows. Section 4.2 is the literature review, including the measurement of financing constraints and investment efficiency in China. Section 4.3 introduces the stochastic frontier approach and our model specification. Section 4.4 briefly describes the data and descriptive statistics, and then reports our main empirical results and robustness tests. Section 4.5 includes the post estimation analysis using the investment efficiency index and investigates how firms' ownerships, regions and industries matter. Section 4.6 is the conclusion.

4.2 Literature review

4.2.1 Indirect measures of identifying financial constraints

4.2.1.1 Cash-flow sensitivities

The pioneering research for this part is Fazzari et al. (1988). FHP (1988) proposes both a theory and an empirical method to investigate the relationship between the firm's real investment decision and its cash-flow sensitivities (ICFS) under an imperfect capital market. For the theory of this paper, FHP (1988) considers that internal finance and external finance cannot be perfectly substituted in an imperfect market. Financially constrained firms cannot obtain external finance—at least the full required amounts, or they do obtain them at significantly high costs. Therefore, these firms must rely on their internally generated funds once an investment opportunity arises. Meanwhile, financially unconstrained firms can easily resort to external funds to finance their investments. Therefore, the constrained firms will exhibit a positive propensity to use cash-flows to finance investment (positive and significant ICFS), and there should be no systematic relationship found for unconstrained firms.

The approach used consists in classifying firms *a priori* as constrained and unconstrained, based on their dividend policy. By assuming that constrained firms, in order to finance their investment, they may pay low dividends to retain internal funds. On the contrary, unconstrained firms will pay high dividends. Based on the classification, FHP selects 422 firms from the Value Line in the period 1970-1984. Empirical study shows the coefficient of (CF/K) is significantly high in constrained firms and there is a downward trend from the constrained to unconstrained firms. This implies the investment expenditure in constrained firms, exhausting all the internal funds, is more sensitive to the fluctuations of the cash flow than firms which are unlikely to face financial constraint.

The work of FHP provides evidence that the ICFS may be a useful measurement of the liquidity constraints. Since then, a slew of studies have followed the FHP to focus on the use of ICFS to identify and measure firms' financial constraints. For instance, Hadlock (1998) for US firms, Hoshi et al. (1991) for Japanese firms; Chapman et al. (1996) for Australian firms; Guariglia (2008) for UK manufacturing firms; Audretsch & Elston (2002) for German manufacturing firms; Kadapakkam et al. (1998) and Bond et al. (2003) for different countries.

The ICFS may be the most commonly used method to measure the financial constraints, however, it also has some pitfalls. The first one is the control for investment opportunities using Q. As we all know, the marginal Q cannot be detected, therefore, the average Q is selected as the proxy (Hayashi, 1982). Nevertheless, this proxy is imprecise, which means the average Q may not show the firm's investment opportunities accurately. In that case, the cash-flow estimation coefficients may both measure the investment demand and the degree of constraint. Moreover, the Tobin's Q is based on the efficient market, which implies the Q of unlisted firms cannot be observed. Hence, this model cannot be employed in the subsequent studies which concentrate on the unlisted firms. Secondly, cash flow itself might contain information about investment opportunities, particularly for firms that face high uncertainty about their investment projects (usually young and growth firms). In fact, Alti (2003) shows that, even after Q correction, firms still present significant ICFS. Thirdly, Kaplan and Zingales (1997, KZ hereinafter) argue that classification criteria used by FHP is flawed. To be more specific, due to precautionary savings and potentially risky adverse management, the dividend policy is an inaccurate sorting variable. Lastly, some research finds that the ICFS relationship is non-monotonic (see Cleary et al. (2007) and Lyandres (2007) for example). They argue that ICFS are U-shaped with respect to constraints owing to the risk associated with firm default and the efforts of investors in trying to avoid corresponding liquidation losses by providing larger amounts to alleviate the risk of default for low levels of internal funds.

The growth cash-flow sensitivity (GCFS) is also based on the ICFS mentioned above by changing the investment to firm's growth variables. A large amount of literature has studied financial constraints by estimating the GCFS. These studies can be roughly divided into three categories, depending on the variable used to measure firm growth: employment growth (e.g. Oliveira and Fortunato, 2006), growth of total assets (e.g. Carpenter and Petersen, 2002) and sales growth (e.g. Fagiolo and Luzzi, 2006).

In terms of the empirical results, Carpenter and Petersen (2002) have found similar relationship with studies using the ICFS method: i.e. there exists a positive relationship between the growth and cash flow sensitivities. However, empirical results in Oliveira and Fortunato (2006) and Fagiolo and Luzzi (2006) have shown negative relationship between cash-flow and the firm growth. Nevertheless, we also need to realize that cash flow is just a proxy for financial constraints (since it cannot be directly measured). Therefore a positive and significant coefficient for cash-flow only tells us that firm growth (or firm's investment) responds positively to increases in cash-flow. Therefore, unless we find a real measure of financial constraints as an explanatory variable, there is not much we can say about the impact of constraints on firm growth or investment.

The above mentioned methods for measuring the cash flow sensitivities have some pitfalls, usually associated with the *a priori* classification of firms, which are worthwhile mentioning.

First, it is doubtable that the segmenting variable (e.g. dividend in the FHP) correctly distinguishes between constrained and unconstrained firms. One example can be found in the KZ (2000), which finds that Microsoft would be classified as a constrained firm according to FHP's classification criteria. In addition, according to Musso and Schiavo (2008), a superior proxy is still yet to be found.

Secondly, when categorizing firms into different groups using continuous segmenting variables, we cannot ensure the cut-off point we use is rational. Since the relationship between the segmenting variable and financial constraints may not be monotonic. For instance, Hadlock and Pierce (2010) shows that even larger and older firms could be as financially constrained as the smaller and younger firms, showing that this relationship may be U-shaped.

Thirdly, it is also unclear that this proxy for constraints is not itself affected by financial constraints. In this situation, one will end up with an *ex ante* classification scheme based on an endogenous variable with respect to constraints (Bond et al., 2003).

4.2.1.2 Euler equation model

Other than the cash-flow model, a slew of literature focuses on measuring investment-cash flow sensitivities with alternative structural model. One of the representative models is the Euler equation, which can refer to Bond and Meghir (1994) and Love (2003). The theoretical method of this model is that, if there exists no financial constraint, the Euler equation derived from the perfect market condition will be accepted. On the contrary, the equation should be rejected if constraint really exists, as the empirical model may omit some financial factors, which leads to misspecification.

To be more specific, we will briefly derive the Euler equation model for the firm-level investment. First, it is essential to introduce a dynamic investment model created by Chirinko (1993). The model assumes firm's investment decision is to maximize the value of firm, which is measured by discounted sum of net revenue. The revenue is affected by technology shocks and the cost of adjustments. Moreover, in both input and output market, firm is price taker. Therefore, the firm's net revenue can be expressed as follows.

$$\Pi_t(K_t, L_t, I_t) = p_t[F(L_t, K_t: \tau_t) - G(I_t, K_t: \tau_t)] - \omega_t L_t - p_t^K I_t \tag{4.i}$$

In this equation, Π_t denotes a firm's net revenue. p_t denotes the output price. $F(L_t, K_t: \tau_t)$ is output function, which includes firm's labour(L_t), capital (K_t), as well as the technology shocks (τ_t). K_t is assumed to be quasi-fixed. Therefore, adjustment cost will occur when a firm is adjusting the capital stock. In this model, the adjustment cost is determined by $G(I_t, K_t: \tau_t)$. In addition, ω_t denotes the labour price while p_t^K is the investment price. Firms maximize the values by maximizing the sum of discounted net profits, which can be expressed as below:

$$V_t(K_{t-1}) = \sum_{s=t}^{\infty}(1+r)^{(s-t)} \{[F(L_s, K_s: \tau_s) - G(I_s, K_s: \tau_s)] - \omega_s L_s - p_s^K I_s\} \tag{4.ii}$$

In equation (4.ii), r is a constant value, which denotes the discount rate. Hence, the firm's value can be simplified as follows:

$$V_t(K_{t-1}) = \max_{I_t, L_t} \Pi_t(K_t, L_t, I_t) + \beta_{t+1} E_t[V_{t+1}(K_t)] \tag{4.iii}$$

In equation (4.iii), $\beta_t = \frac{1}{(1+r)}$ is the firm's discount factor. The maximized value of firm's investment is constrained by the following function of capital accumulation.

$$I_t = K_t - (1-\delta)K_{t-1} \tag{4.iv}$$

In equation (4.iv), the problem of maximization can be solved by the Lagrange Multiplier. Therefore, the solution can be described by the first order condition as below.

$$-\left(\frac{\partial \Pi_t}{\partial I_t}\right) = \lambda_t \tag{4.v}$$

$$\lambda_t = \left(\frac{\partial \Pi_t}{\partial K_t}\right) + (1-\delta)\beta_{t+1}E[\lambda_{t+1}] \tag{4.vi}$$

λ_t denotes the shadow value of inheriting one addition unit of capital in period t. Equation (4.vi) can be transformed by repeated substitutions as follows:

$$\lambda_t = E_t\left[\sum_{s=0}^{\infty}(1-\delta)^s\,\beta_{t+s}\left(\frac{\partial \Pi_{t+s}}{\partial K_{t+s}}\right)\right] \tag{4.vii}$$

In equation (4.vii), if we partial differentiate Π_t by I_t, we will then obtain

$$\frac{\partial \Pi_t}{\partial I_t} = -p_t\left(\frac{\partial G}{\partial I_t}\right) - p_t^k = \lambda_t \tag{4.vii}$$

In order to derive the benchmark model, it is essential to define the adjustment cost. Generally, the adjustment costs are assumed as quadratic and affected by the investment, capital stock and the technology shock. Therefore, it can be written as below.

$$G(I_t, K_t) = b/2\,\left(\frac{I_t}{K_t} - a - \tau - e_t\right)^2 K_t \tag{4.ix}$$

In equation (4.ix), a is investment rate while e_t denotes the error term. The benchmark model can be derived as below if we substitute the adjustment cost in equation (4.ix) into (4.viii).

$$\frac{I_t}{K_t} = a + \frac{1}{b}\left[\left(\frac{\lambda_t}{p_t^k} - 1\right)\frac{p_t^k}{p_t}\right] + \tau + e_t \tag{4.x}$$

In the model, λ denotes as the sum of discounted marginal revenue capital product. Therefore, firm's investment depends on the expected investment opportunities. Based on the benchmark model, Bond and Meghir (1994) first remove λ_t (i.e. shadow value) by substituting first order condition for investment, the λ_t in equation (4.v) into equation (4.vi), which can be written as,

$$-\left(\frac{\partial \Pi_t}{\partial I_t}\right) = \left(\frac{\partial \Pi_t}{\partial K_t}\right) + (1-\delta)\beta_{t+1}E\left[\frac{\partial \Pi_{t+1}}{\partial I_{t+1}}\right] \tag{4.xi}$$

Consider the equation (4.i) (net revenue function), when the perfect market assumption holds, the equation (4.xi) can be changed to

$$(\frac{\partial G}{\partial I_t}) = E_t[\varphi_{t+1}] + (\frac{\partial F}{\partial K_t} - \frac{\partial G}{\partial K_t} - \frac{r_t}{p_t}) \qquad (4.xii)$$

φ_{t+1} denotes a real discount factor, while $\frac{r_t}{p_t}$ is the user cost of capital. Consider the function of adjustment cost, the Euler equation model can be expressed as follows,

$$\frac{I_t}{K_t} = a(1 - E[\varphi_{t+1}]) + E[\varphi_{t+1}(\frac{I_{t+1}}{K_{t+1}})] + \frac{1}{b}(\frac{\partial F}{\partial K_t} - \frac{\partial G}{\partial K_t} - \frac{r_t}{p_t}) \qquad (4.xiii)$$

The main advantages of the Euler equation model are as follows: first, it can control the effects of future expected returns to the investment spending. To be more specific, the investment can be estimated with the expected investment one period ahead. The ahead value can be replaced by the real value in t+1. Second, the Tobin's Q, which may not be exactly measured, is excluded. Additionally, the type of data required for the empirical test can be found in many datasets, as it is mostly based on information available in firms' balance sheets. However, the disadvantage of the Euler equation model is also obvious. The Euler equation is a structural model with a series of assumptions, and the null hypothesis may be rejected if any one of the assumptions is loosened (indeed, this can be regarded as a common problem for all the structural models) (Coad, 2010). However, in this case, we cannot interpret the rejection as caused by the constraint or the other factors (e.g. the type of the adjustment cost or the irreversibility of the investment). In addition, the model cannot detect the constraint if the degree remains unchanged in the observation period. Lastly, this model is based on parameter tests and does not directly produce a variable that can be used in subsequent estimations.

4.2.1.3 Summary

Overall, based on the comments for the methods above, there are some common advantages and shortcomings for these models. In terms of the virtue, when using these methods, the data is easy to obtain as the required information is mainly from firms' balance sheets. In that case, the statistical organizations (e.g. national statistical office in each country, World Bank and OECD) can provide such information for very large and representative samples of firms operating in a certain region or country.

The common problems can be concluded as follows: firstly, these measures rely on theoretical assumptions needed to construct the underlying models for empirical equations. Secondly, none of the measures produces a variable that is firm-specific and time-varying. Conversely, they only provide a test, based on regression coefficients, for the presence of financial constraints within a subsample of firms.

4.2.2 Direct measures of identifying financial constraints and Indexes

Compared with the indirect methods mentioned above, a direct measure of financial constraints can prove to be a useful tool that avoids the theoretical and measurement issues. One of the direct ways is the company reports. In the world, major firms usually provide an annual report with their end-of year financial statement. These reports contain rich qualitative information regarding a firm's financial position and need for external finance. Hence, scholars can employ this information to assign each firm a level of financial constraints. Representative cases could be found in KZ (1997) and Hadlock and Pierce (2010). More specifically, Kaplan and Zingales (1997) collect data not only from the companies' financial statement and annual report, but also from the management discussions and some shareholders' letters.

There are three main steps for researchers to transfer this qualitative information to quantitative data. First, searching these statements for keywords and expressions that are symptomatic of the presence of financial constraints (Hadlock and Pierce, 2010). Second, assigning a level of financial constraint for each firm according to the information reported. Finally, if possible, this qualitative information should be complemented with quantitative information (e.g. financial variables) in order to build a final score of financial constraints (KZ, 1997).

The major advantage of using this type of approach is the richness of information available for the researcher to sort firms according to their level of constraints. In addition, if the financial reports can be collected periodically, the financial constraint variable can be generated as firm-specific and time-varying. The major drawback is related to the sample size and representativeness of corresponding samples. To be more specific, although company reports provide rich and relatively accurate information, it is difficult to obtain such information for a large number of firms. Reports are only made available by a small number of firms, indicating that the sample may be biased. Additionally, the firms with public financial reports are usually established firms, which are usually treated as non-constrained firms.

In order to avoid some of the disadvantages (e.g. non-firm-specific variable) of direct and indirect measures of financial constraints, the combination of different types of information and different variables into indexes provides a useful tool in the analysis of firms' constraints. There are three main indexes in the previous studies, as follows:

Based on the Euler equation approach (see section 4.1.2), Whited and Wu (2006) construct an index by using a structural parameter of Whited's (1992) model—the shadow cost of equity finance— that is set to be a function of observable firm characteristics. In practice, the strategy estimates the Euler equation model's resulting empirical equation. In this framework, the shadow cost of finance is set, outside of the model, to be a function of observable "financial health" variables. As a result, a vector of coefficients is obtained and that is then used to build the index (known in the literature as the WW index).

The merits and faults of the WW index are similar to those of the Euler equation discussed in the preceding section. Specifically, the advantage is that data collection for constructing the index is not hard, only balance sheet data and financial markets information are needed. The major disadvantage is the index results from a highly parameterized structural model (as in section 4.1.2). Additionally, due to the number of parameters involved in the underlying model, this approach is of far more complex implementation than any other measure discussed in this section.

An alternative strategy without using a sophisticated structural underlying model was created by Cleary (1999). Using multiple discriminant analysis (MDA), we can examine which variables are likely to influence the characterization of a firm as either financially constrained or not. Specifically, first, apply a segmenting variable that enables the distinction of firms into two (or more) mutually exclusive groups. Second, use MDA to assess the ability of each independent variable (determinants of financial constraints) to distinguish a firm between groups. As a result, the index can be built using the coefficients estimated through MDA. Using the same groundwork, we can also employ the segmenting variable to distinguish two (or more) groups of firms (e.g. financially constrained and non-financially constrained) and then estimate the determinants of financial constraints. The resulting coefficients will then be used to build the index.

The major disadvantage of this method is similar to the *ex-ante* firm classification issue mentioned in section 4.1.1, that is, the need to have a superior segmenting variable that correctly discriminates between financially constrained and unconstrained firms. Cleary (1999) assumes that dividend policy serves as such a variable because firms reducing dividends are likely to be constrained, whereas a firm will only increase dividends if it knows it can maintain them (financially unconstrained). However, if the segmenting variable does not consistently discriminate between constrained and unconstrained firms, the resulting index will biased.

This index, first introduced by Musso and Schiavo (2008), ranks firms in a certain class (e.g. industry or region) that is reasonably homogeneous. These rankings are computed with a number of variables that are found to have a given relationship to financial constraints (i.e. proxies). Hence, a score of constraints can be built based on the relative rankings of a given number of variables for a certain firm, within a certain class. The motivation to disaggregate firms into homogeneous classes is to account for specificities that may affect the relationship of the proxies and the genuine level of constraints.

According to Bellone et al. (2010), this method can be applied following two steps. First, identify a number of variables that can serve as proxies of financial constraints. For each of these variables, compute the relative position of each firm to the corresponding class mean. Second, collapse the rankings from all the proxies into a single score of financial constraints. To be more specific, if a firm is very old and large, and has a higher dividend payout ratio, it is considered not to be constrained. If the reverse is true, then such a firm is assigned as constrained (Bellone et al., 2010).

There are twin disadvantages of this index. Firstly, the score variable is of an ordinal nature. Nothing guarantees that the difference between a firm scoring 1 and 2 is the same as the difference between the levels 2 and 3. As a result, the score of constraints must be analysed as an ordinal variable, which has significant implications in the choice of the estimation procedure. Secondly, if the relationship between the proxy and the effective level of constraints is non-linear, the final score will misrepresent the level of constraints. For example, if the relationship is U-shaped, we will see some firms assigned the maximum score facing a lower level of constraints.

4.2.3 Measurement of Investment Efficiency

The investment efficiency is not directly related to the proxies of the financial constraints. However, it is still essential to make a brief review about literature on the investment efficiency in China since this chaper will also discuss the investment efficiency in the post estimation analysis.

In the literature, the investment efficiency is mainly examined at a macro level. Zhang (2003) investigates China's economic growth via the aggregate level of investment growth. Using the macro data between 1978 and 2000, Zhang finds an improvement of investment efficiency, especially in the rural industrialization and proliferation of small firms in non-state sectors. Bai et al. (2006) uses the data from China's national accounts and estimates the capital return rate in China. They find that, despite the high investment rate during the reform period, the rate of return to capital has been dramatically increased. This fact may due to the fast growth speed in total factor productivity (TFP hereafter). In addition, there is a trend for the increment of capital-intensive industries during this period. However, not all the literature on China's investment performance shows a positive view. For instance, Rawski (2002) argues that, from the 1990s, China shows a relative low investment returns and extensive excess capacity across many sectors. In fact, this is a signal that capital in some industries is underused, especially in the industries dominated by the SOE firms. Qin and Song (2009) use the province-level data during 1989 to 2004 and find that there is still a tendency of overinvestment in China if overinvestment is defined as the difference between actual and profit-maximized investment, despite increasing allocative efficiency and improving technical efficiency associated with aggregate investment.

Recently, there is some research employing micro-level data to find evidence on Chinese firms' investment performance. However, the results are also inconclusive. For example, using a listed firm-level data from Chinese stock market, Liang (2006) shows that listed firms' investment return has been high and rising since late 1990s, as a result of the declining share of investment undertaken by listed SOEs. On the other side, Lian and Chung (2008) consider both the effects of financial constraints and agency costs, and discover underinvestment rather than overinvestment for Chinese listed firms.

4.2.4 Gaps and hypotheses

In the preceding sections, we overview the existing frameworks used to identify and measure financial constraints. It is clear that researchers in this field have a wide range of different measures, with perhaps complementary advantages and disadvantages. Therefore it is hard to clearly point a superior approach. To sum up, some major common shortcoming of the methods mentioned above are as follows:

First, some of the methods are based on the strict theoretical assumptions, which is in low practicability. For example, the Euler equation model and WW indexes (based on the Euler equation).

Second, a large number of methods need to make *a priori* classification of firms (e.g. cash-flow sensitivities and MDA index), as discussed in the section 4.1.1, is problematic.

Third, for most of the measures above, they produce a financial constraint variable that is not firm-specific and time-varying.

Fourth, for some methods (e.g. company report), the available samples are small and biased.

Fifth, regarding the investment efficiency in China, there exists controversy among the literature. Moreover, the current researches only show indirect ways to measure the investment efficiency.

Indeed, the shortcomings listed above can limit the reliability of the stylized studies. However, the stochastic frontier analysis can overcome or avoid those disadvantages. For instance, Wang (2003) employs this approach to measure the financial constraint across Taiwanese listed firms. Wang imposes the distribution assumption on the constraint, and then the effect of financing constraints can be identified and quantified without splitting samples by *a priori* criteria. Wang finds that cash flow is positively correlated with firm’s fixed investment under the financial constraint. In addition, cash flow can also reduce the variance of the liquidity constraints. This research also reveals that the firms’ investment efficiency increased during Taiwan’s financial liberalization, and this effect is particularly significant for small firms.

Following Wang's (2003) research, Bhaumik et al. (2012) uses Indian manufacturing firms between 1997 and 2006 to conduct a similar estimation. This research both compares the stylized regression on the ICFS and the stochastic frontier. The findings indicate that, although the results from the SFA are in consist with the stylized method, the SFA provides better information regarding the degree of financial constraints over time. In addition, the results from SFA can provide better insights about the impact of individual firm characteristics on the degree of constraint.

Nevertheless, to our best knowledge, only two empirical studies discussed above use the SFA to investigate the firm's investment and financial constraint. In addition, the database used in these empirical studies are both listed firms, which are usually regarded as non-constrained firms. Additionally, in their model specification, they do not consider some China-specific features (e.g. the controlled variables showing the ability to access bank loans are not included). This gap is also shown in their post-estimation analysis. For instance, the literature does not show the difference of investment efficiency based on firms' ownership, or the locations. However, these features have been verified in the literature that affects the degree of financial constraint of Chinese firms (see Ding et al.(2013) and Guariglia & Liu (2014) as instances). Therefore, it is essential to apply the SFA to measure the financial constraint for Chinese unlisted firms, with augmentation of the China-specific features.

Based on the discussion above, we can now propose the hypotheses of this chapter as below.

Hypothesis 4.1: firm's investment and its cash flow should be positively associated.

Hypothesis 4.2: larger firms and firms with better financial status are less likely to be financially constrained.

4.3 Methodology and model specification

4.3.1 An introduction to the Stochastic Frontier Approach

In the stylized literature, the Stochastic Frontier Approach is first proposed and mainly used in measuring firm's productivity. Traditional literature in the productivity field (see Solow (1957) as an example) assumes that all the difference between the aggregate outputs and the factor inputs can be due to the technological progress. However, Farrell (1957) points out that not all the producers can reach their frontier of production function. In that case, technical inefficiency exists in the most of the producers. In order to improve the Solow residual method, Aigner and Chu (1968) first proposed the idea to decompose the TFP to frontier technology and technical inefficiency.

However, according to Aigner et al (1977) and Meeusen and Broeck (1977), the shortcoming of Aigner and Chu (1968) is obvious: all deviations from the frontier are assumed to be the result of the technical inefficiency despite some of the deviations coming from measurement errors and statistical noise. A feasible solution is to introduce another random variable representing statistical noise. Hence, Aigner et al (1977) and Meeusen and Broeck (1977) proposed the stochastic frontier production function model as shown below:

$$y_{it} = f(x_{it})exp(v_{it} - u_{it})$$

(4.i)

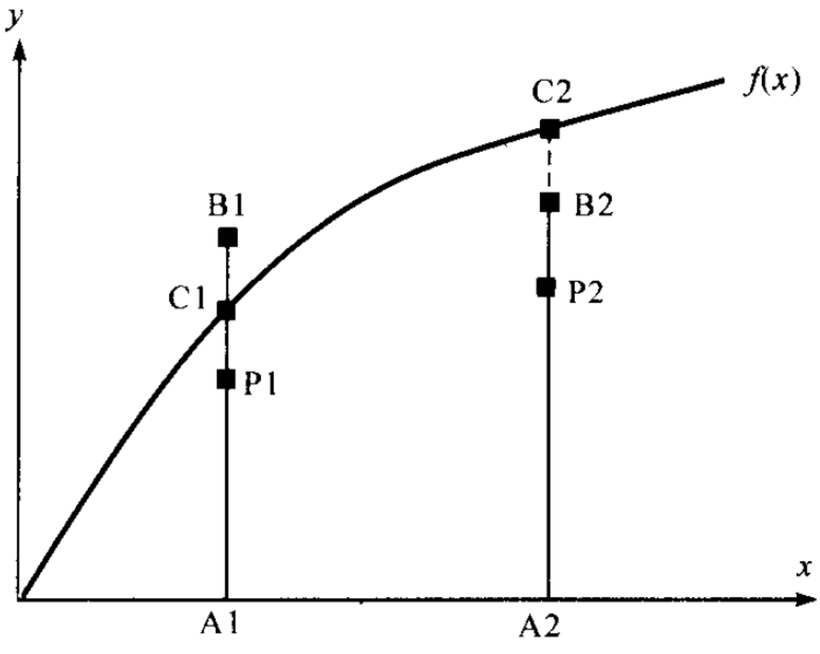
Where y_{it} denotes the output of producer i at year t. x_{it} is a vector containing the input factors. $f(\cdot)$ is production function, which can be regarded as the technical frontier of the producer. v_{it} denotes the measurement errors and other statistical noises. u_{it} is a non-negative random variable associated with technical inefficiency. This model is called a stochastic frontier product function since the output values are bounded from above by the production function. Some of the producers cannot reach their frontiers, because they are influenced by the stochastic disturbance (v_{it}) and technical inefficiency (u_{it}). However, if the v_{it} can be adequately identified, the stochastic disturbance can be viewed as white noise, which means its mean value should be 0. In that case, the technical efficiency (TE) of the producer can be expressed as the ratio between the expectation of output and the expectation of stochastic frontier. The formula can be written as below:

$$TE = \frac{E[f(x)exp(v-u)]}{E[f(x)exp(v-u)|\, u=0]} = exp(-u_{it}) \quad (4.ii)$$

Such a frontier can be depicted as in Figure (4.i) where we plot the inputs and output of two firms, 1 and 2. In this figure, the x axis expresses the input where the y axis denotes the output. $f(x)$ is the deterministic part of the frontier production. Firm 1 inputs A1 and outputs P1. The frontier output B1 for firm 1 lies above the deterministic part of the frontier production (C1) only because the noise effect is positive (i.e. $v_a > 0$). Compared with its production frontier, the Technical efficiency of firm 1 should be $A1P1/A1B1$. Similarly, for firm 2, since its noise effect is negative (i.e. $v_b < 0$), its frontier output lies below the deterministic part of the frontier production. Hence, the technical efficiency of firm 2 should be $A2P2/A2B2$. In addition, it can also be found that the observed output of firm 1 lies below the deterministic part of the frontier as the sum of the noise and inefficiency effects is negative (i.e. $u_a - v_a < 0$).

As discussed above, if we can obtain the multiple observations from the producers, we can then estimate the frontier production $f(x)$ and then calculate the technical efficiency of each producer in the dataset.

Fig.4.i Stochastic production frontier and cases for two firms



Source: Coelli et al., 2005.

4.3.2 Recap of the stylized specification

In the stylized literature on investment decisions and financial constraints, the most common used regression model is from Fazzari et al. (1988), which employs 422 US manufacturing firms between 1970 and 1984 period. In this model, Fazzari et al. (1988) assumes the investment decisions of a firm will be captured by the Tobin's Q if the market imperfection does not exist, and the firm is not financially constrained. However, when a firm is constrained, the investment decision will be affected by cash flow, a proxy for the firm's internal liquidity. Based on these assumptions, a generalized regression model in the stylized literature can be expressed as follows:

$$\frac{I_{it}}{K_{i,t-1}} = f\left(\frac{X_{it}}{K_{i,t-1}}\right) + g\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \varepsilon_{it} \tag{4.1}$$

Where:

I indicates the investment, X indicates the vector of variables capturing investment opportunities, CF indicates cash flow, K denotes the capital, and v indicates the independently and identically distributed (i.i.d.) error term. In Fazzari et al. (1988), the vector X contains both Tobin's Q and current and past sales, which may also capture the investment opportunity of a firm. In the literature, the variants of this model are usually estimated by the fixed effect panel regressions (for examples, see Aivazian et al., 2005; Guariglia, 2008; Ding et al., 2013).

In most of the stylized literature, the samples are usually divided into groups that have different levels of information cost and then different likelihoods of being financially constrained. In this case, the differences of the sensitivity of investment to cash flow for these groups capture the differences in the extent of credit constraint. Fazzari et al. (1988) classifies firms based on dividend payout, while other research uses firm characteristics such as firm size or age. However, these criteria are *ad hoc*, especially when they are potentially time varying. Kaplan and Zingales (1997) argue that the cash flow sensitivity to investment could lead to erroneous conclusion when firms are classified into groups of high or low costs of information by dividend payout or any other criterion. In addition, according to Laeven (2003), *a priori* classification of firms into groups using other criteria may also result in incorrect conclusions.

4.3.3 Using stochastic frontier approach in measuring financing constraints

Based on the discussion in the section 4.3.1, we can see the stochastic frontier approach can be employed in the cases where the one-sided technical inefficiency can be viewed as deviation of the outcome variable from its desirable maximum/minimum value, which is technically unobserved.

In this chapter, we investigate the relationship between the firm's level of financial constraints. Hence, we can use the stochastic frontier model to estimate the optimum investment level and the actual investment level under the environment of financial constraint. To be more specific, the desired level of investment of each firm is not observable, and the actual (observed) amount of investment by a firm should be less than (or equal to) the desired investment level, because of factors such as informational cost or firm-specific risk. Therefore, in this chapter, the one-sided technical efficiency term can be viewed as the effect of financial constraint on the level of investment.

The main advantages of the stochastic frontier model can be listed as follows. First of all, unlike the stylized research (see Fazzari et al. 1988; Ding et al. 2013 for instances), the stochastic frontier approach can directly measure a firm's level of financial constraint, rather than measuring the marginal effects by using the pooled OLS or system GMM methods. Secondly, in the stylized studies, the data would be classified by some subjective criteria before the estimation. This may lead to sample selection bias (Kaplan and Zingales, 1997; Cleary, 1999). In the stochastic frontier approach, the regression can be conducted without splitting samples. Thirdly, by using stochastic frontier approach, we can generate a variable to directly show the firm's investment efficiency level for each individual firm and at each time point. However, there is a significant shortfall in the stochastic frontier approach. The creators (Aigner et al., 1977; Meeusen & Broeck, 1977) assume that the stochastic frontier model does not have the endogeneity problem; i.e. there should no reversed causation between the dependent and independent variables, nor correlation between the controlled variables. This violates the reality in the corporate finance area. However, in the stylized approach, the IV approach can be used to overcome the potential endogeneity, and some methods (e.g. GMM) can automatically employ the lagged variable to overcome the reversed causation. Nevertheless, to our best knowledge, there is no effective way in the stochastic frontier approach to tackle the endogeneity problem.

Based on the stylized literature Fazzari et al. (1988), a firm's investment decision depends only on its future prospect, which is captured by Tobin's Q, and perhaps also by the current and past sales. If other firm characteristics (e.g. cash flow) have an impact on the investment decision, the firm will be regarded as a financially constrained one. Therefore, based on the assumptions mentioned above, Wang (2003) and Bhaumik et al. (2012) argue that, in the absence of capital market imperfections, a firm's investment decision will be defined as follows:

$$ln\left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} = \alpha + \beta lnQ_{it} + \gamma ln\left(\frac{Sale_{it}}{K_{i,t-1}}\right) + \theta_t + \mu_i + v_{it} \tag{4.2}$$

Where θ and μ capture time and firm fixed effects, and e is the i.i.d. error term. This regression model, therefore, defines the efficient investment function (frontier). However, the firms in our sample database (which will be formally discussed in the next section) are all private firms, implying that the Tobin's Q is not available. Hence, according to Lang et al. (1996) and Bond et al. (2004), we employ the firm's sales growth as the proxy of the investment opportunity. There are two main reasons to select the sales growth as the proxy variable. First, based on the accelerator theory of investment, the level of investment expenditure will depend on the level of production. Hence, the increment of the production will lead to the increase of the capital stock, indicating that the firm will face more investment opportunities. The sales growth can reflect the historical level of production, so it is a feasible proxy for the investment opportunity. Secondly, Bond et al. (2004) points out that compared with the Tobin's Q, sales growth can rectify the mismeasurement of the investment opportunity to some extent. Hence, the frontier investment function for the private firms can be defined as follows:

$$ln\left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} = \alpha + \beta lnSG_{it} + \gamma ln\left(\frac{Sale_{it}}{K_{i,t-1}}\right) + \theta_t + \mu_i + v_{it} \tag{4.3}$$

Where SG denotes the sales growth.

In the presence of financing constraints, the observed investment-to-capital ratio is less than the efficient (optimal) investment-to-capital ratio in equation (4.3). So the difference between this efficient investment-to-capital ratio and the observed investment-to-capital ratio is attributed to financing constraint. This difference can be represented by a non-negative term u. More specifically, the observed investment-to-capital ratio can be written as:

$$\left(\frac{I_{it}}{K_{i,t-1}}\right) = \left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} \exp(-u_{it}) \quad (4.4)$$

and that is:

$$ln\left(\frac{I_{it}}{K_{i,t-1}}\right) = ln\left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} - u_{it} \quad (4.5)$$

The equations (4.3) and (4.5) together define the stochastic frontier formulation of the investment function, and can be estimated using the distributional assumptions on u and ε that were discussed above. It is evident that the stochastic frontier approach gives us not only the estimates of the parameters of the investment function but also observation-specific estimates of the one-sided investment efficiency term u as well, and therein lies the key to the application of the stochastic frontier approach to the literature on firm-level financial constraints.

In the equations (4.4) and (4.5), we can see that the $I_{it}/I_{it}^{SF} = \exp(-u_{it})$. Hence, the I_{it}/I_{it}^{SF} can be viewed as an index of the investment efficiency which is between 0 and 1. For instance, an efficiency score of 0.75 indicates that the firm's investment is at 75% of its desired level. Alternatively, u times 100 can be regarded as the percentage shortfall of investment from its desired (frontier) level, which is attributed to financial constraints. In that case, u can be viewed as investment inefficiency. It measures shortfall of investment from the desired level due to the presence of financial constraints.

Therefore, the main advantage of the stochastic frontier approach is that the estimated values of u can provide not only whether a firm is financially constrained or not, but also the degree of this constraint. To be more specific, the higher value of u indicates the greater impact of financial constraints on investment. In addition, the investment efficiency index (i.e. I_{it}/I_{it}^{SF}) has the advantage that it captures the combined impact of all the constraining variables on the extent of credit constraint. By contrast, alternative methodologies such as fixed effects panel regression models captures only the marginal impact of individual firm characteristics (Z) on investment of the average firm, and hence do not show us whether an individual firm is credit constrained or not, and if so by how much. By using the stochastic frontier approach, it is possible to display distributions of the extent of financial constraints of the firms from the efficiency indexes, and compare distributions of financial constraints across firm characteristics and over time. More importantly, the application of the stochastic frontier approach eliminates the requirement to use problematic criteria (e.g. dividend payout) to split the sample, which may lead to bias (Kaplan and Zingales, 1997).

Another advantage of the stochastic frontier approach is that we can directly measure the impact of firm characteristics (*Z*) on the degree of financial constraint, rather than measure the marginal impact of these characteristics on average level of investment in sample firms. This can be applied by extending the basic model discussed above to install the *Z* variables. In this chapter, we will employ three Z variables: the asset, leverage and coverage. The asset is the proxy of the firm's size. In the stylized literature (see Beck and Demirguc-Kunt (2006) for example), compared with the small firms, the larger firms are in a better position to reduce the threat of the adverse selection by providing collateral. Hence, the larger firms are less likely to be constrained firms. The leverage and coverage are the proxies of the financial fragility (Hericourt and Poncet, 2009; Guariglia et al., 2011).

These variables can be accommodated into the model via the inefficiency term. To be more specific, the inefficiency term u_{it} can be set at two different kinds of distribution: half normal distribution and truncated normal distribution.

When we assume u_{it} subjects to a half-normal distribution, i.e. $u_{it} \sim N(0, \sigma_u^2(\mathrm{Z}_{it}))$, $u_{it} \geq 0$ where $\sigma_u(\mathrm{Z}_{it}) = \exp(\gamma'\mathrm{Z}_{it})$, and $\gamma'\mathrm{Z}_{it}$ can be written as follows:

$$\gamma'\mathrm{Z}_{it} = \varphi\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \pi Size_{it} + \rho Leverage_{it} + \omega Coverage_{it} \quad (4.6)$$

Where the exponential specification is used to ensure that the $\sigma_u(\mathrm{Z}_{it})$ is not negative and γ is the parameter vector associated with these Z variables. In this specification, $E(u_{it})$= $\sqrt{2/\pi}\exp(\gamma'\mathrm{Z}_{it})$. Hence, it is easy for us to find the marginal effect of individual *Z* variables on investment inefficiency. To be more specific, if *Z* variable is lower than *u*, the marginal effect will tell us by what percent investment will increase if *Z* is increased by 1%.

In addition, when the u_{it} is set at the truncated distribution, i.e. $u_{it} \sim N(\mu(Z_{it}), \sigma_u^2(Z_{it}))$, $u_{it} \geq 0$ where $(Z_{it}) = \exp(\delta' Z_{it})$, and $\delta' Z_{it}$ can be written as follows:

$$\delta' Z_{it} = \varphi\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \pi Size_{it} + \rho Leverage_{it} + \omega Coverage_{it} \qquad (4.7)$$

We specify the μ and σ^2 to be determined by same variables because we assume the variables which influence the mean value of the distribution may also impact on the variance of distribution. However, the effects may not be same, and even have the possibility to be opposite (Wang, 2003). The economics of the mean μ can be explained as whether the parameters in Z vector influence the μ or not. In our case, this indicates whether the firm characteristics affect the firm's financial constraint (Wang, 2003). Similarly, the variance of σ^2 can be viewed as whether the parameters affect the σ^2 . In our research, this can be regarded as how the firm heterogeneities influence the uncertainty of financial constraint (Battese and Coelli, 1995 and Bhaumik et al., 2012).

Actually, the model specification used in the OLS or fixed effect panel regressions can be regarded as special cases of the stochastic frontier model. For instance, if we consider the specification following variation of equation (4.1) as follows, including the Z variables shown in equation (4.6) and (4.7):

$$\left(\frac{I_{it}}{K_{i,t-1}}\right) = \alpha + \beta lnSG_{it} + \gamma ln\left(\frac{Sale_{it}}{K_{i,t-1}}\right) + \varphi\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \pi Size_{it} + \rho Leverage_{it} + \omega Coverage_{it} + \theta_t + \mu_i + \varepsilon_{it} \qquad (4.8)$$

Next, consider the stochastic formulation of the baseline equation as follows:

$$ln\left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} = \alpha + \beta lnSG_{it} + \gamma ln\left(\frac{Sale_{it}}{K_{i,t-1}}\right) + \theta_t + \mu_i + \varepsilon_{it} - u_{it} \qquad (4.9)$$

If we denote $v_{it} = \varepsilon_{it} - u_{it}$, it is clear that v_{it} will have a non-zero mean because u_{it} is not negative, and this will incur a problem by using OLS since it assumes the zero mean error. This problem can be avoided by rewriting v_{it} as $v_{it} = \varepsilon_{it} - (u_{it} - E(u_{it})) - E(u_{it}) = \varepsilon_{it}^* - E(u_{it})$ where $\varepsilon_{it}^* = 0$ by construction. Then we can get an error term which has a zero mean but need to account for the extra term $-E(u_{it})$ in the estimation.

Hence, we can assume as follows:

$$-E(u_{it}) = \varphi\left(\frac{CF_{it}}{K_{i,t-1}}\right) + \pi Size_{it} + \rho Leverage_{it} + \omega Coverage_{it} \tag{4.10}$$

In this case, we will go back to the equation (4.7). Therefore, we can use the equation (4.7) to start the estimation of a frontier model. This specification could ensure the $-E(u_{it}) < 0$. So we can analyze the degree of financial constraint of a firm in each year. As mentioned above, this is an advantage compared with the common used fixed effect panel model.

4.4 Data and empirical results

4.4.1 Data source and summary statistics

Our data are collected from the annual accounting reports filed by industrial firms with the National Bureau of Statistics (NBS) over the period 2000–2007. All state-owned enterprises and other types of enterprises with annual sales of five million yuan (usually called `above scale' firms) or more are covered. These firms operate in the manufacturing and mining sectors and public utilities are in all 31 Chinese provinces or province-equivalent municipal cities. The NBS database provides balance sheets and profit and loss accounts of firms in a standardized format, making the numbers comparable across the firms. Therefore, data on variables such as sales, investments and cash flows can be directly obtained from the database or easily computed. The NBS database also provides information on financial ratios such as the leverage ratio and coverage ratio that is our measure of financial fragility, as well as information on firms' ownership. Our definition of variables is consistent with the existing literature.

Our sample covers 66,500 unlisted firms, which corresponds to 273,013 firm-year observations. This is an unbalanced panel, each of the sample firms have at least three years continuous records between 2000 and 2007. We drop observations with negative sales and negative total assets minus total fixed assets. We also eliminate firms that do not have complete records on our main regression variables. In order to control for the potential influence of outliers, we clip observations in the one percent tails of each of the regression variables.

Table 4.1 shows the summary statistics of the variables we use in the regression. Overall, the figures are self-explanatory, and only one figure needs some further explanation. In table 4.1, the high level of cash flow ratio (52.9% on average) shows that the majority of Chinese private firms choose to save a large quantity of cash. According to the precautionary saving theory, cash accumulation behaviour is interpreted as a method to solve financing constrained problems (Fazzari et al., 2000). The precautionary saving is important for Chinese firms because the financial system in China is bank-based, and the state-owned firms are more likely to get loans than the non-state-owned firms (Megginson et al., 2014). In our sample, 96.16% of the firms are non-state-owned ones. Hence, it is easy to understand the high level of cash flow ratio among the sample firms.

Table 4.1 Summary Statistics

Variable	mean	medium	st.dev
(Log) Sales growth	3.039	3.131	1.012
(Log) Sales(t)/Capital(t-1)	7.852	5.246	7.804
Cash flow(t)/Capital(t-1)	0.529	0.314	0.608
(Log)Assets	4.287	4.177	1.353
Leverage	0.557	0.571	0.251
Coverage	18.237	5.143	46.511
Number of firms		66500	
Number of observations		273013	

Note: Coverage is shown as multiples.

4.4.2 Regression results and discussion

Prior to report the main regression results, it is meaningful to discuss the interpretations of the *Z* variables in the stochastic frontier model. The hypothesis of the signs of the coefficients can be seen in the table 4.2, as follows:

Table 4.2 expectations of the coefficients

	(Stylised) fixed effects model	Stochastic frontier model
Cash flows	+	-
(Log) assets	+	-
Leverage	-	+
Coverage	+	-

We can use the coefficient of cash flow variable for explanation. In the stylized literature (see Fazzari et al., 1988; Whited, 1992; Guariglia, 2008; Ding et al., 2013, as examples), the positive coefficient of the cash flow is a signal of the existence of financial constraint. However, in the stochastic frontier model, the cash flow variable does not explain investment directly, but explains the investment inefficiency or the degree of the financial constraints. Therefore, if the financial constraints can be alleviated by the cash flow (i.e. reduce the investment inefficiency), the cash flow variable will have a negative coefficient in the stochastic frontier model. Hence, the rest of the table can be similarly explained in terms of the opposite signs between the stylized models and stochastic frontier model. The (log) assets are widely used as a proxy of capturing the firm's information problem (Carpenter et al., 1994; Gilchrist and Himmelberg, 1995; Guariglia and Liu, 2014). Firms with larger assets may have better ways for providing collateral to alleviate the information problem. For any given industry, larger firms tend to be more mature, so the market usually can more easily access the firm's information. As for the leverage and coverage, these two variables are employed to examine the firm's ability to access the external finance from the banks (Lang et al., 1996; Guariglia et al., 2011; Bhaumik et al., 2012; Guariglia and Liu, 2014). This is crucial for the Chinese firms' estimation since China is a bank-based economy (Allen et al., 2005). Lower leverage and higher coverage means the firm is in better financial health, meaning that it is more likely to obtain bank loans.

In table 4.3, we reported the estimation results of stochastic frontier models with fixed effects. The column (1) is the estimation of the equation (4.3), which is the frontier equation. In this model, we assume the investment inefficiency $u \sim N(\mu(Z_{it}), \sigma_u^2)$, $u_{it} \geq 0$, but does not attempt to explain it. The column (2) is the estimations of both frontier and inefficiency model under the assumption of truncated normal distribution. In column (3), we set the error term as the truncated-normal distribution. In column (4), we set the error term as the half-normal distribution.

The regression results indicate that the sales growth and the investment decision are generally positively related. To be more specific, considering the firm characteristics (i.e. the results in column (4)), the firm's fixed investment will increase 0.151% when the sales growth increases by 1%. This result is as expected. In addition, the results for current sales ratio also show a significant positive effect on investment. Similarly, considering the firm characteristics, the firm's investment will increase 0.583% when the sales ratio increases by 1%. As the sales growth in our model is the proxy of the Tobin's Q, which is viewed as the variable capturing investment opportunity in the stylized literature (see Fazzari et al. (1988) for an example). Hence, we can conclude two points as follows. Firstly, the sales growth can capture the firm's investment opportunity. Secondly, sales have a positive impact on investment decisions.

Before analyzing how the firm's financial constraint is affected by its characteristics, it is meaningful to take a glance at the significance of the regression results. The column (2) and (3) are the estimations of the model where the inefficiency term is set at truncated normal distribution. The results in table 4.3 illustrates that the majority of coefficients in the inefficiency equation of μ (i.e. the mean value of the error term) are not significant, implying that firm's characteristics may not impact on the financial constraint. Nevertheless, this is not the case in the stylized literature. On the other hand, as seen in the results in the column (4), where the error term u is set at the half-normal distribution, the estimations indicate that the firm heterogeneities do affect the firm's financial constraint. Moreover, the estimations in column (2) also show slight higher, but similar results to those in column (4). In the meantime, the higher results may also means there is an upward bias in the estimation. Hence, we can assume that the half-normal distribution of the inefficiency term u is better than the set of truncated-normal distribution. The discussions below will all be based on the results in column (4).

Table 4.3 Main regression results from the stochastic frontier approach

	(1)	(2)	(3) $\sigma^2 = 0$	(4) $\mu = 0$
Frontier equation				
(Log) Sales growth	0.142***	0.137***	0.163***	0.151***
	(0.000)	(0.000)	(0.000)	(0.000)
(Log) Sales(t)/Capital(t-1)	0.608***	0.565***	0.596***	0.583***
	(0.000)	(0.001)	(0.000)	(0.001)
Inefficiency equation of μ				
Cash flow(t)/Capital(t-1)		-0.167	-0.140	
		(0.204)	(0.327)	
(Log)Assets		-0.032	-0.029	
		(0.116)	(0.212)	
Leverage		0.001**	0.001**	
		(0.0002)	(0.00021)	
Coverage		0.003	0.001	
		(0.027)	(0.033)	
Inefficiency equation of σ^2				
Cash flow(t)/Capital(t-1)		-0.368***		-0.356***
		(0.000)		(0.002)
(Log)Assets		-0.052**		-0.041***
		(0.025)		(0.001)
Leverage		0.006***		0.005***
		(0.000)		(0.000)
Coverage		-0.025***		-0.022***
		(0.000)		(0.000)
Number of firms	66500	66500	66500	66500
Number of observations	273013	273013	273013	273013

Note: The column (1) is the results of the frontier equation without the effect of u_{it} (Eq. (4.3)). The column (2) is the results of the model captured the impact of the firm characteristics. (includes both Eq. (4.6) and (4.7)). The column (3) set the variance equal to zero (i.e. the estimation of Eq (4.7) only). The column (4) set the mean value equal to zero (i.e. the estimation of Eq (4.6) only).

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

We then turn to discuss the firm characteristics that may impact on firms' financial constraints. In the column (4), we introduce the factors which are discussed in the previous part. Overall, the signs of estimated coefficients of Z variables in table 4.3 are generally as expected in table 4.2.

For the cash flow, the coefficient -0.356 indicates that the 1% increment of cash flow ratio will result in 0.356% decrement of the investment inefficiency. Hence, the cash flow can reduce the level of financial constraints, or conversely, the investment is positively related to the cash flow. This is in line with the stylized literature regarding the firm investments. In terms of the firm size (log assets), the result can be interpreted in that the 1% increment of firm size will result in 0.041% decrement of the investment inefficiency. This result is also consistent with the mainstream literature because the larger firms have more collateral, which makes them more likely to obtain bank loans. In addition, the large firms are assumed to be more diversified and less likely to bankruptcy.

The results for coefficient of the financial variables are also reasonable. First, for the leverage, the value of coefficient is 0.005, indicating that a 1% increase of leverage will lead to 0.005% increment of investment inefficiency. The effect is significant, but very small. This is not surprising: the very small change of the leverage may not significantly impact the ability of the firm to borrow. However, a large change of the leverage does impact the firm's borrowing. The interpretation for the coverage ratio is similar. High coverage is positively related to the firm's investment decision. However, the value of coefficient indicates that the small change of coverage may not impact the firm's investment.

4.4.3 Robustness check

4.4.3.1 Fundamental Q

In the baseline model, we employ the sales growth as the proxy to capture the firm's investment opportunity. As we discussed, this is because the Tobin's Q is not available for a non-listed firm. However, besides the sales growth, we can also measure the investment opportunities with a dynamic and forward-looking method, which is usually called fundamental Q (we denote it as *FQ*). In our paper, we follow the method suggest by Gilchrist and Himmelberg (1995) through estimations of a set of VAR (vector autoregressive). The calculation can be expressed as below:

$$FQ_{i,t} = b'(I - \lambda A)^{-1} x_{i,t} \tag{4.11}$$

$$x_{i,t} = A x_{i,t-1} + \eta_i + \gamma_t + u_{i,t} \tag{4.12}$$

In the equation (4.11), b denotes a constant vector, which only contains 1 and 0. I denotes the unit matrix. λ denotes the discount rate, which can be calculated by $\lambda = (1-\delta)/(1+r)$. A is the coefficient matrix. $x_{i,t}$ is a vector, which follows a stationary stochastic process with a first-order autoregressive representation (shown in equation (4.12)). According to Gilchrist and Himmelberg (1995), the vector $x_{i,t}$ includes profit rate, total factor productivity and the sales rate. η_i denotes the unobservable firm specific effects. γ_t is a vector of aggregate shock to all firms and $u_{i,t}$ is a vector of error terms. In that case, the two estimation equations can be written as follows:

Frontier equation:

$$ln\left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} = \alpha + \beta FQ_{i,t} + \gamma ln\left(\frac{Sale_{it-1}}{K_{i,t-2}}\right) + \theta_t + \mu_i + v_{it} \tag{4.13}$$

Inefficiency equation:

$$\left(\frac{I_{it}}{K_{i,t-1}}\right) = \alpha + \beta FQ_{i,t} + \gamma ln\left(\frac{Sale_{it-1}}{K_{i,t-2}}\right) + \pi Size_{it-1} + \rho Leverage_{it} + \omega Coverage_{it} + \theta_t + \mu_i + \varepsilon_{it} \tag{4.14}$$

Compared with the baseline inefficiency equation (4.10), the equation (4.14) dropped the cash flow variables. This is because 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 collinearity problem.

Table 4.4 shows the results for using the Fundamental Q. The coefficients of $FQ_{i,t}$ indicate that the Fundamental Q can also adequately capture firm's investment opportunities. To be more specific, considering the firm characteristics (i.e. the results in column (8)), the firm's fixed investment will increase 0.287% when the sales growth increases by 1%.

The signs of the coefficients are in line with the results shown in table 4.3, and all the signs are as expected with significant coefficients. In that case, we can say that the Fundamental Q is a valid proxy to replace the sales growth. One may find that the values of coefficients in the table 4.4 are higher than those in baseline estimations displayed in the table 4.3. This may be due to the change of the measurement of investment opportunity.

Table 4.4 Robustness check: Fundamental Q

	(7)	(8)
Frontier equation		
FQ	0.271***	0.287***
	(0.000)	(0.011)
(Log) Sales(t-1)/Capital(t-2)	0.264***	0.223***
	(0.001)	(0.001)
Inefficiency equation		
(Log)Assets(t-1)		-0.063***
		(0.011)
Leverage		0.009***
		(0.000)
Coverage		-0.021***
		(0.000)
Number of firms	66500	66500
Number of observations	185416	185416

Note: The column (5) is the results of the frontier equation without the effect of u_{it} (Eq. (4.13)).

While the column (6) is the results of the model captured the impact of the firm features. (Eq. (4.14))

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

4.4.3.2 Lagged independent variables

In order to overcome the potential endogeneity from the independent variables, it is essential to do some robustness tests. Hence, we lagged the independent variables in the frontier equation (4.3), cash flow ratio and firm size in the inefficiency equation (4.8), for once. In that case, the two estimation equations can be written as follows:

Frontier equation:

$$ln\left(\frac{I_{it}}{K_{i,t-1}}\right)^{SF} = \alpha + \beta lnSG_{it-1} + \gamma ln\left(\frac{Sale_{it-1}}{K_{i,t-2}}\right) + \theta_t + \mu_i + v_{it} \tag{4.15}$$

Inefficiency equation:

$$\left(\frac{I_{it}}{K_{i,t-1}}\right) = \alpha + \beta lnSG_{it-1} + \gamma ln\left(\frac{Sale_{it-1}}{K_{i,t-2}}\right) + \varphi\left(\frac{CF_{it-1}}{K_{i,t-2}}\right) + \pi Size_{it-1} + \rho Leverage_{it} + \omega Coverage_{it} + \theta_t + \mu_i + \varepsilon_{it} \tag{4.16}$$

Table 4.5 shows the results for the lagged variable regression. The signs of the coefficients are in line with the results shown in table 4.3, and all the coefficients are significant. In that case, we can assume all the (lagged) independent variables are properly justified. One may find that the values of coefficients in the table 4.5 are lower than those of non-lagged variables in the table 4.3. This is easy to understand, since the firm's characteristics from the previous years may also impact on the current year. However, the impact should be smaller than those occurring in the current year.

Table 4.5 Robustness check: lagged independent variables

	(5)	(6)
Frontier equation		
(Log) Sales growth(t-1)	0.109***	0.097***
	(0.002)	(0.000)
(Log) Sales(t-1)/Capital(t-2)	0.548***	0.572***
	(0.102)	(0.094)
Inefficiency equation		
Cash flow(t-1)/Capital(t-2)		-0.183***
		(0.004)
(Log)Assets(t-1)		-0.022***
		(0.006)
Leverage		0.004***
		(0.000)
Coverage		-0.023***
		(0.000)
Number of firms	66500	66500
Number of observations	185416	185416

Note: The column (5) is the results of the frontier equation without the effect of u_{it} (Eq. (4.15)). While the column (6) is the results of the model captured the impact of the firm features. (Eq. (4.16))

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

4.5 Post-estimation analysis: the investment efficiency index

4.5.1 Investment efficiency index

As discussed above, one advantage of the stochastic frontier model is that this approach enables us to estimate a measure of financial constraint for each individual firm and at each point in time. In the methodology part, we have shown that such an investment efficiency index (IEI thereafter) can be estimated by the equations (4.4) and (4.5). To recapitulate, the IEI is bounded in (0, 1). High IEI indicates that the firm's actual investment level is close to its (unobserved) desired level. Hence, if the IEI is close to zero, it means the firm shows a severe financial constraint. Similarly, when the IEI is approaching to one, we can believe that the firm is not affected by the liquidity constraint.

4.5.2 Firm ownership in China

Since China is a transitional 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 (SoE), private firms (private), foreign firms (foreign), and collective firms (collective).

SoE firms refer to the firms that the state holds the majority of the shares (more than 50%). Basically, the state gets the shares from two ways. Wei et al. (2005) states 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 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 shareholder called a legal entity. The question here is that some of the legal entities also include state-owned legal entities, it may not be appropriate if we include these entities in the private category (Ding et al., 2013). Our database cannot allow us to make a distinction between the state legal entities and private legal entities, which indicates we cannot exclude the former from the private category.

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

4.5.3 Analysis on IEI for entire sample and different ownerships

Table 4.6 shows the summary statistics of the IEI for the entire sample firms across all observation years. For the overall investment efficiency, the mean value is 0.343, indicating that the actual investment for the sample firms only achieved 34.3% of their optimum level in the observation years. Hence, it can be seen that the majority of Chinese private firms show a high degree of financial constraint.

In terms of the firms with different ownerships, the SoE firms show the lowest average IEI (25.1%), which is much lower than the average value. This is in accordance with the stylized literature of Chinese firms' investment (Ding et al., 2013; Chen and Guariglia, 2013, Greenaway et al., 2014). The main reason for the low efficiency of SoE firms is that they can obtain benefits from soft budget constraints (Bai et al., 2006). Moreover, some studies point out that SoE firms have more severe agency problems than the other firms in China (Chen et al., 2012). Private firms show the highest investment efficiency (35.9%), which is not very in line with the literature. One possible reason for this result is that private firms in China are hard to access external finance (i.e. bank loans). In order to survival, the private firms have no way but to increase the investment efficiency.

Table 4.6 Summary Statistics of the Investment efficiency index (IEI)

Ownership	mean	medium	st.dev	number of firms	observations
Entire sample	0.343	0.26	0.263	66500	273013
SoE	0.251	0.170	0.233	2437	10470
Private	0.359	0.303	0.265	47521	192140
Foreign	0.299	0.226	0.248	9505	40054
Collective	0.320	0.248	0.260	7037	26821

Note: each two mean values from different sample groups have been assessed by the mean-comparison test (t-test) and the results are all significant at 5% level. To save space, these p-values are not reported.

Fig. 4.1 shows the IEI distribution for the entire samples. Overall, the distribution is roughly subject to a left-skewed one. The largest proportion of firms is located at the least efficiency interval (i.e. 0%-20%). Meanwhile, the distribution curve shows a swell in the high efficiency interval (i.e. 80%-90%). It can be considered that a large quantity of the inefficient firms are located below the average level of investment efficiency.

Fig.4.1 IEI distribution for the entire sample

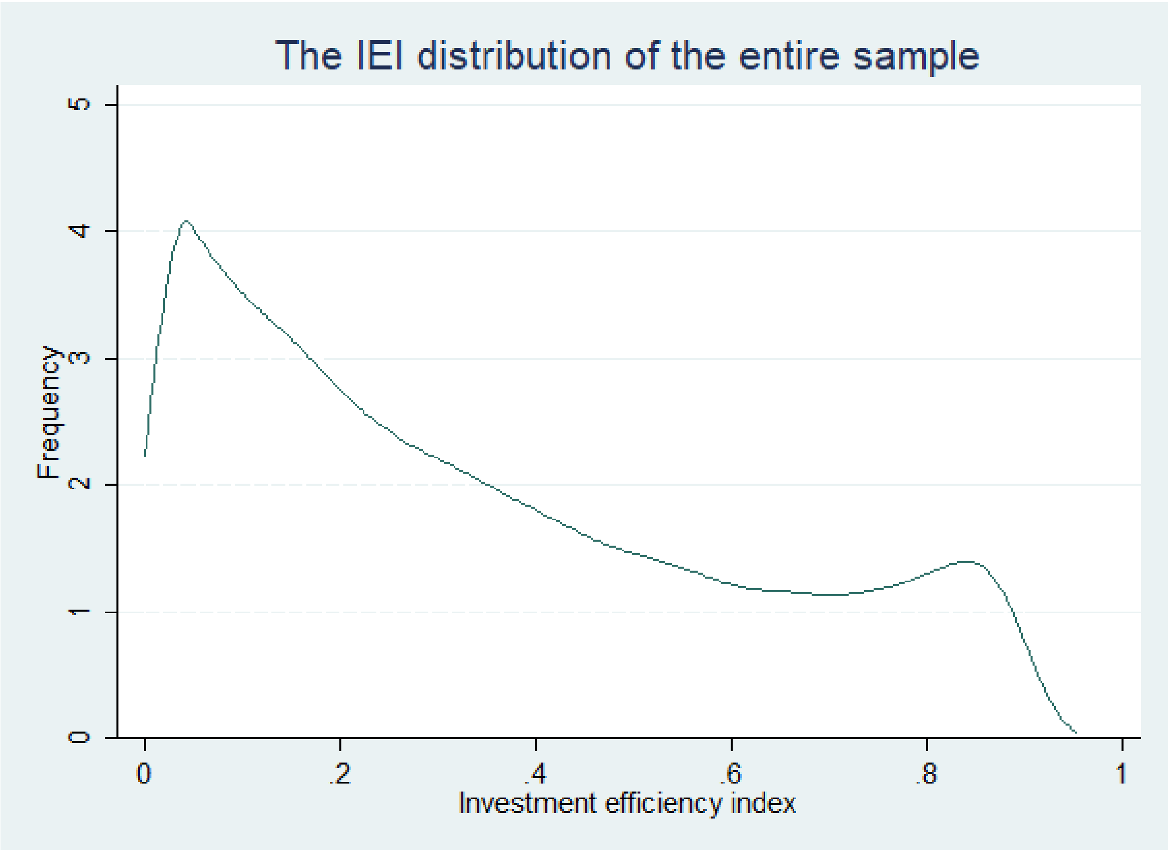


Fig.4.2 displays the IEI by different ownerships. The four sub-graphs have the same scale of axes in order to make the comparisons. It is clear that the SoE firms perform worst in the inefficiency interval while the private firms perform best. To be more specific, compared with the other groups, a larger proportion of SoE firms are located at the least efficient interval (i.e. 0%-20%). Similarly, compared with the other groups, the private firms show a smaller proportion in the least efficiency interval. The patterns of foreign and collective firms are very similar, which is in line with the small difference of the mean and median values between the two groups

Fig.4.2 IEI distribution by different ownerships

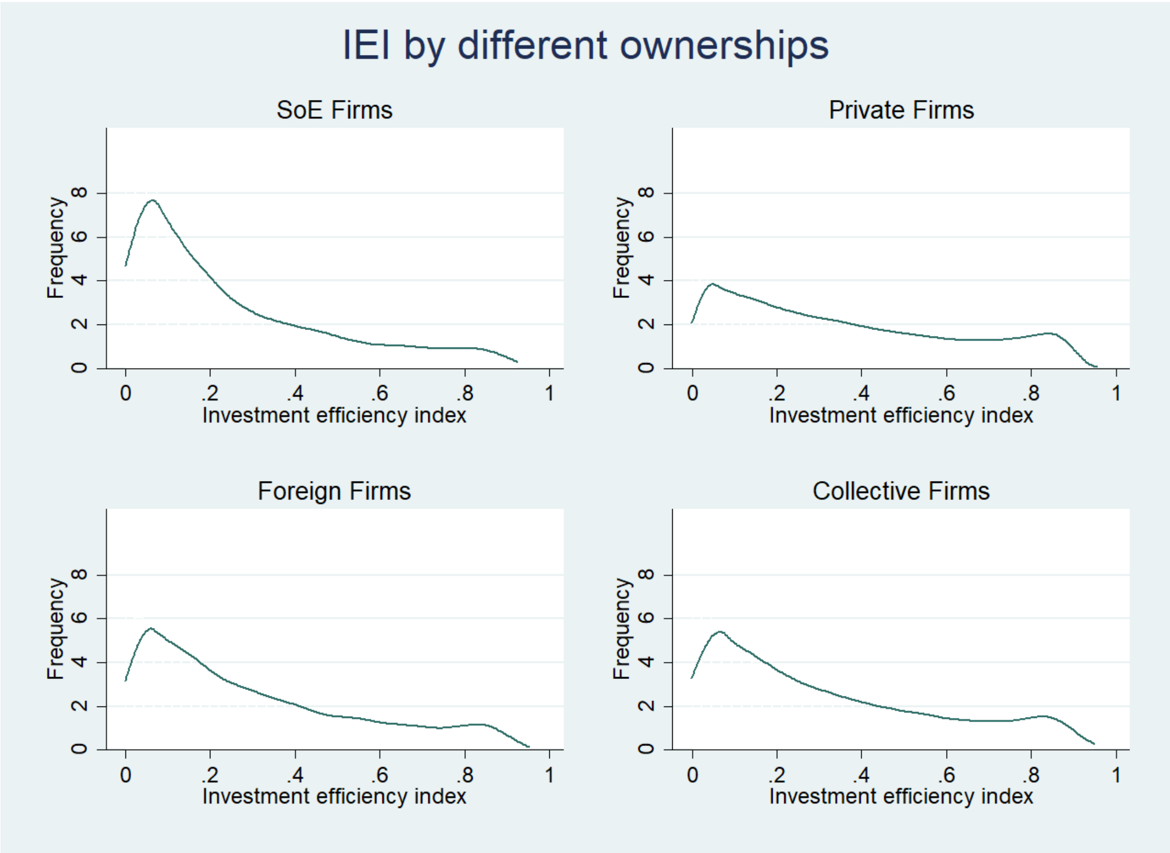
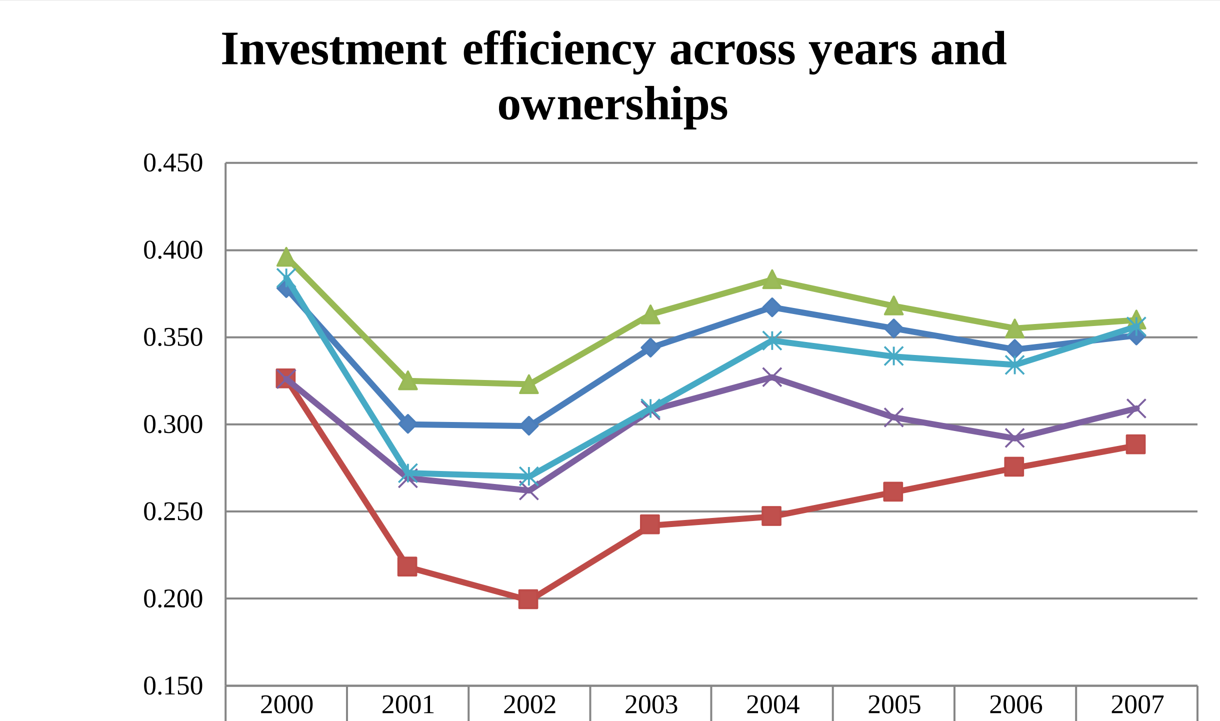


Fig.4.3 shows the distribution comparison across the observation years and different ownerships. For the entire sample, the IEI peaks at 2000 and then quickly decreases to bottom at 2002, and then it slightly rises in the following years. The overall tendencies of the four ownerships are similar to that of the entire sample. The private firms still show the highest level of the investment efficiency over this period while the SoEs show the lowest. The levels of the foreign and collective firms do not differ so much. There are also two interesting points, as follows. Firstly, in the year 2000, the four sub groups do not show large differences, the gaps are enlarged in the bottom period (2001-2002). Secondly, although the SoE is the least effective group, its efficiency starts to increase monotonously, resulting in shrinking the gap with the other groups.

Fig.4.3 IEI comparison across years and ownerships



	2000	2001	2002	2003	2004	2005	2006	2007
Entire	0.378	0.300	0.299	0.344	0.367	0.355	0.343	0.351
SoE	0.326	0.218	0.199	0.242	0.247	0.261	0.275	0.288
Private	0.396	0.325	0.323	0.363	0.383	0.368	0.355	0.360
Foreign	0.326	0.269	0.262	0.308	0.327	0.304	0.292	0.309
Collective	0.384	0.272	0.270	0.309	0.348	0.339	0.334	0.356

4.5.4 Comparison of IEI among different level of legal institution and ownerships

In China, the firms in the different regions may face different level of constraints. For example, the coastal areas have the highest GDP per capita, while the western regions show the lowest GDP per capita. Regarding the external fund access, the coastal regions have a more developed banking system, which may make financing constraints less confined (Firth et al., 2009; Lin et al., 2011). Although there are many reasons to explain why the level of economic development varies across the regions, one of the underlying factors is the level of marketization (i.e. legal institution). In firm level, different level of marketization can affect the firm's financial decisions. For instance, Li et al. (2009) points out that disparities in regional institution levels matter for firms' leverage decisions. In addition, this paper also finds if region improves the quality of its institutional environment, alternative long-term financing instruments will become available and local firms will then reduce their reliance on long-term debt financing. Therefore, it is meaningful to connect the IEI to the level of legal institution.

In terms of the marketization index, we employ the index composed by Fan et al. (2010). The index consists of 23 components which are focusing on the five aspects below: relationship between government and markets, development of non-state sector in the economy, development of product markets, development of factor markets, as well as development of market intermediaries and legal environment. We first calculate the average index at province level between year 2000 and 2007. Then we divided the samples into two groups: high legal institution and low legal institution. The high institution group includes firms located in the provinces where the average marketization indexes are in the top half, while the low institution group contains firms in the provinces where the average marketization indices are in the bottom half.

Table 4.7 shows the summary statistics of the IEI across different level of marketization. In our sample, the majority of firms (72.9%) are situated in the provinces with high level of institution. This is not surprising, since a better legal environment is helpful for firms. In terms of the IEI, firms in regions with high legal institution (0.351) is dramatically higher than their counterparts (0.316). In the Fig.4.4, firms located in regions with better marketization is less likely to be situated at the least efficiency interval (i.e. 0%-20%) than their counterparts. In the meantime, they are more likely to be found at the high efficiency interval (i.e. 80%90%)show similar results. Specifically, western firms perform worst in the inefficiency interval whilst the central firms perform a bit better than the coastal firms in that interval.

Table 4.7 Summary Statistics of the Investment efficiency index (IEI)

Ownership	mean	medium	st.dev	number of firms	observations
Entire sample	0.343	0.26	0.263	66500	273013
High legal institution	0.351	0.289	0.203	48545	199846
Low legal institution	0.316	0.247	0.281	17955	73167

Note: mean values from different sample groups have been assessed by the mean-comparison test (t-test) and the results are all significant at 1% level. To save space, these p-values are not reported.

Fig.4.4 IEI comparison among levels of legal institution

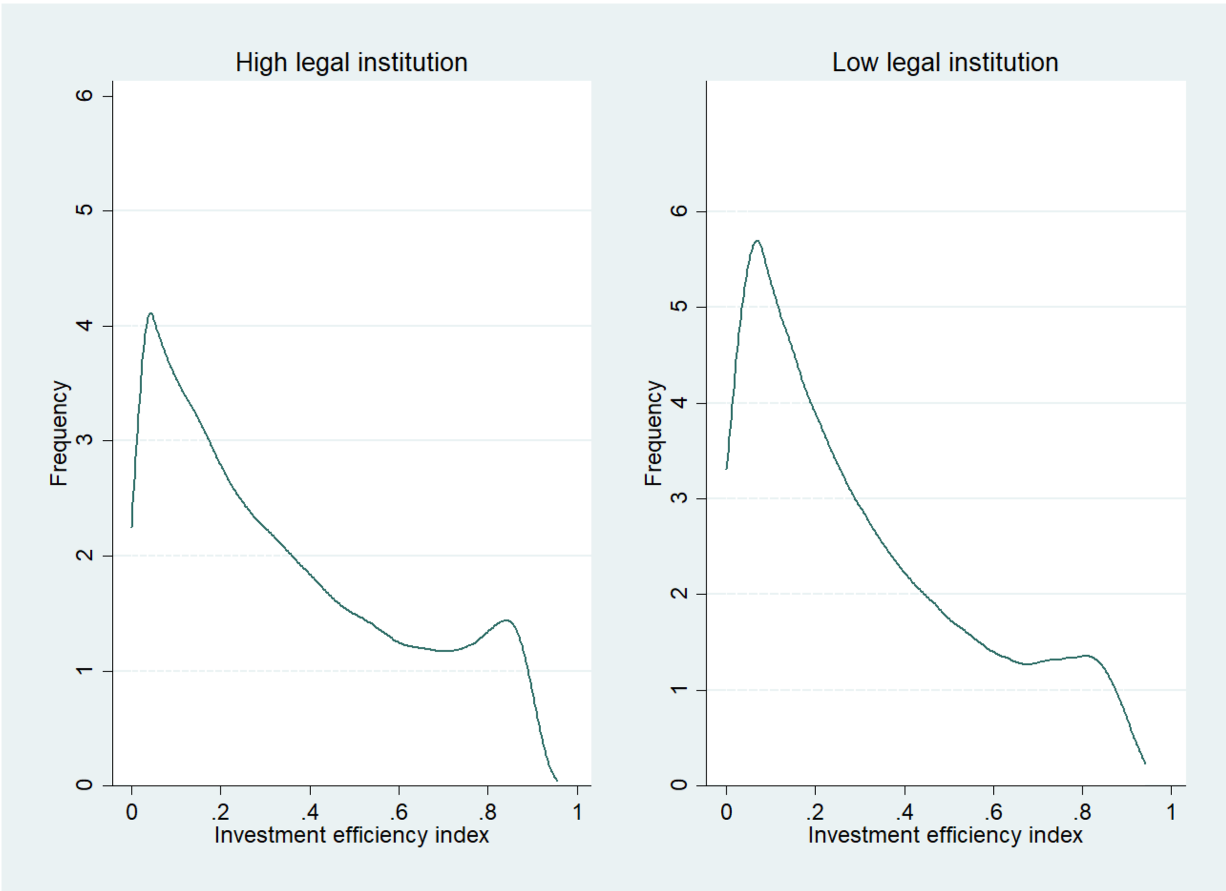
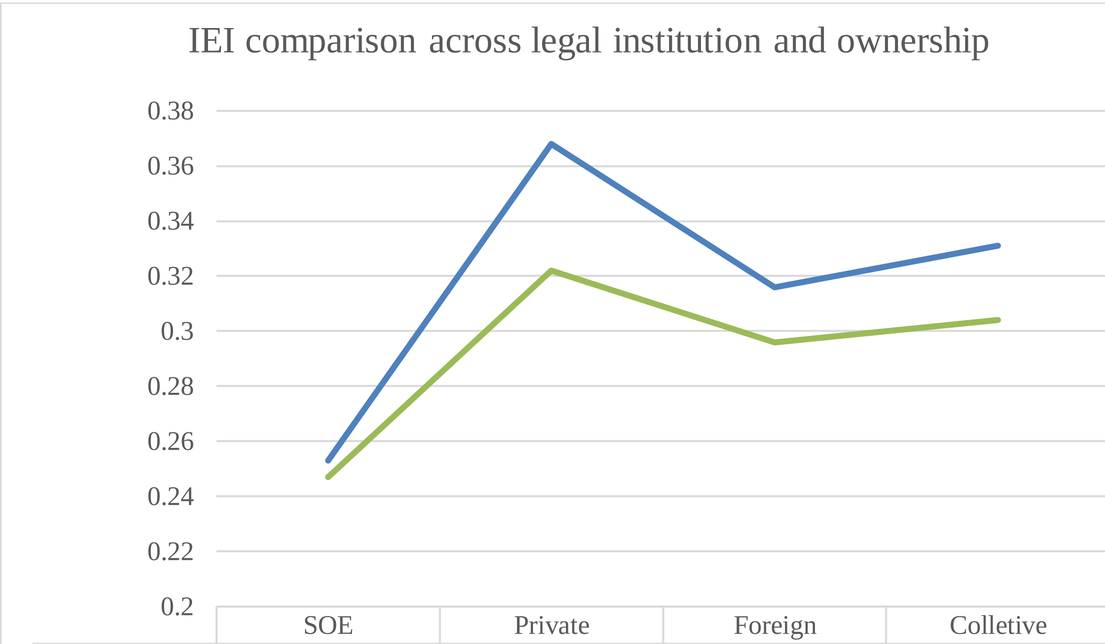


Fig.4.5 compares the IEI considering the legal institutions and ownerships. In terms of firms in different level of marketization, regardless of the ownership, firms in the regions with high legal institution level exhibit high IEI than their counterparts in the low legal institutional regions. SOE firms show the lowest IEI, which is in line with the previous discussion (see fig 4.2 and 4.3). The major difference is in the private firms. Those in the regions with superior marketization are 4.6% higher in the IEI than the firms in provinces with poor inferior marketization. Among the non-SOE groups, foreign firms in both groups show the lowest IEI. This is also in accordance with the previous findings, implying that foreign firm may exhibit lower level of financial constraints than the private and collective firms.

Fig.4.5 IEI comparison across legal institution and ownership



	SOE	Private	Foreign	Colletive
High legal	0.253	0.368	0.316	0.331
Low legal	0.247	0.322	0.296	0.304

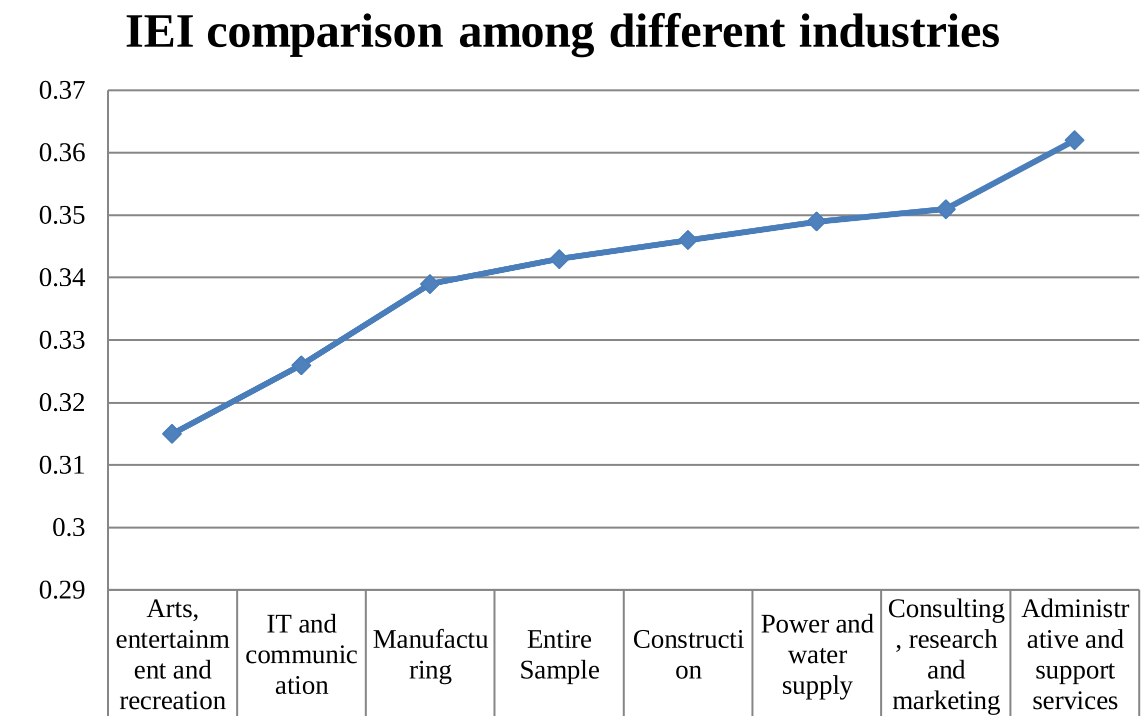
4.5.5 Comparison of IEI among industries

In the stylized ICFS literature, the industry variable is usually used as a dummy to capture the investment opportunities (Brown and Peterson, 2009). To be more specific, the industry dummy variable is often combined with the time dummy to capture the time-varying demand shocks at the industry level. This method is widely used in the recent literature (for instance, see Brown et al., 2009; Duchin et al., 2010; Ding et al., 2013). However, as discussed in the literature and methodology sections, the stylized ICFS literature only shows marginal effects of the investment cash-flow sensitivities. In this part, we can make a direct comparison among firms in different industries.

The NBS database provides the code of industries based on the 4th version of International Standard Industrial Classification of All Economic Activities (United Nations, 2008) both in aggregated and disaggregated level. In this case, we choose the section-aggregated level to conduct the analysis. To be more specific, our sample mainly contains firms from seven sections: manufacturing, power and water supply, construction, it and communication, consulting, research and marketing, administrative and support services, and arts, entertainment and recreation. The first four sections can be regarded as the secondary industries while the other three can be viewed as tertiary industries (IMF, 2015). Based on the classification, we first make an overall comparison among the industries and set the overall IEI as the benchmark.

Fig.4.6 shows the comparisons of average IEI among the industries. It is clear that the tertiary industries perform better IEI than that in the second industries. To be more specific, 2 of 3 industries in the tertiary sector (consulting, research and marketing, administrative and support services) have an above average IEI. In addition, the two industries are the first and second highest ones among all sections. However, the least efficient industry (arts, entertainment and recreation) is also belonging to the tertiary industries. In terms of the industries in the second sectors, the highest IEI is 0.349 while the lowest is 0.326. This indicates there may not exist remarkable difference among industries in this sector.

Fig.4.6 IEI comparison among different industries

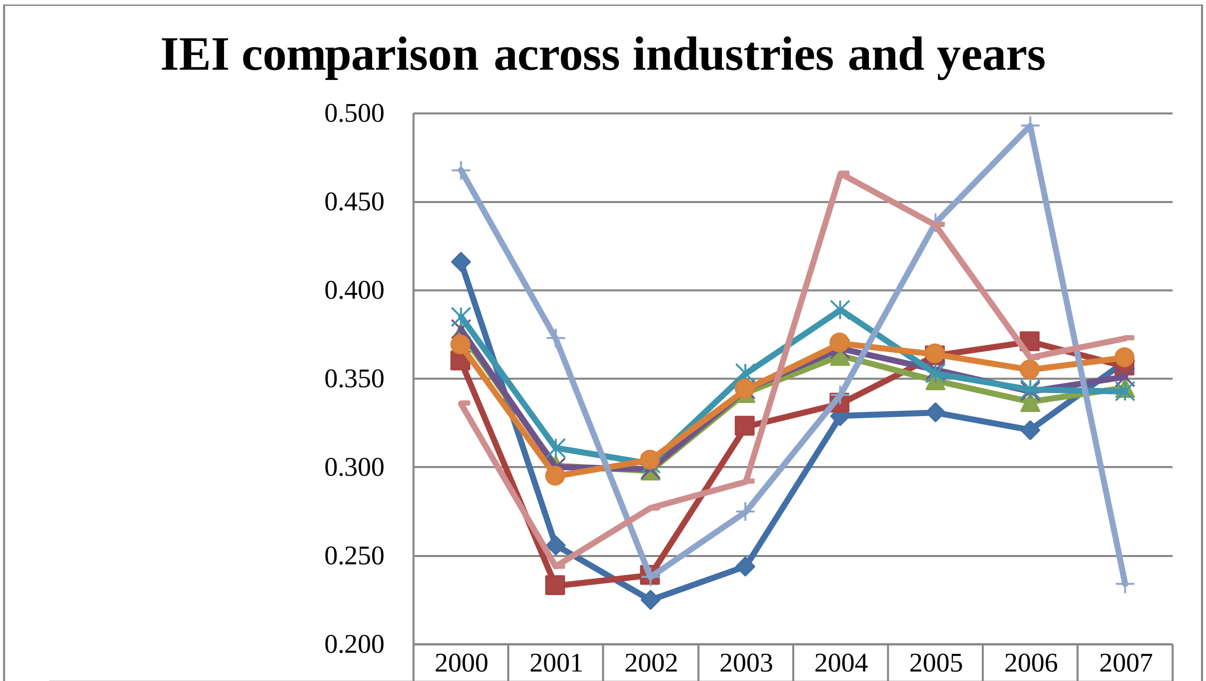


	Arts, entertainment and recreation	IT and communication	Manufacturing	Entire Sample	Construction	Power and water supply	Consulting, research and marketing	Administrative and support services
IEI	0.315	0.326	0.339	0.343	0.346	0.349	0.351	0.362

Note: each two mean values from different sample groups have been assessed by the mean-comparison test (t-test) and the results are all significant at 5% level. To save space, these p-values are not reported.

Fig. 4.7 provides more details about the IEI for industries in different observation years. In terms of the industries from the secondary sectors, the majority of IEIs show very similar trend with the IEI of the entire sample. However, the industries from the tertiary sector show large IEI variations from that of the entire sample. Especially for the consulting, research and marketing, and administrative and support services. For example, the consulting, research and marketing industry displays a large positive variation from the average IEI at the beginning observation year, then it sharply declined to its lowest level at 2002. In the later years, it shows a rising trend again and peaks at 2006. However, it suddenly falls at 2007. Overall, the tertiary sectors show better investment efficiency than those in the secondary sectors. However, the secondary sectors are more stable as regards the investment efficiency. This may be due to the features of industries in the secondary sectors: they are mainly the manufacturing firms, meaning that although they may be affected by the business cycles, however, they can access relatively stable external finance than firms in the tertiary sectors.

Fig.4.7 IEI comparison across industries and years

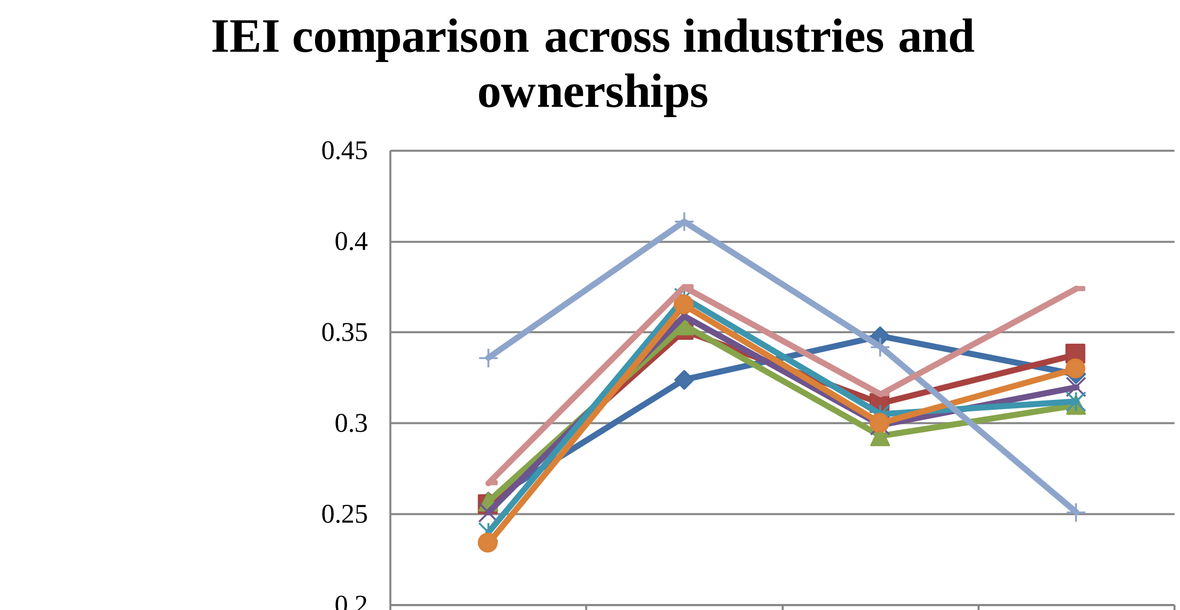


	2000	2001	2002	2003	2004	2005	2006	2007
Arts, entertainment and recreation	0.416	0.256	0.225	0.244	0.329	0.331	0.321	0.360
IT and communication	0.360	0.233	0.239	0.323	0.336	0.363	0.371	0.357
Manufacturing	0.376	0.301	0.298	0.342	0.363	0.349	0.337	0.345
Entire sample	0.378	0.300	0.299	0.344	0.367	0.355	0.343	0.351
Construction	0.385	0.311	0.302	0.353	0.389	0.353	0.344	0.343
Power and water supply	0.369	0.295	0.304	0.344	0.370	0.364	0.355	0.362
Consulting, research and marketing	0.468	0.373	0.238	0.275	0.341	0.438	0.493	0.234
Administrative and support services	0.336	0.244	0.277	0.292	0.466	0.437	0.362	0.373

Note: each two mean values from different sample groups have been assessed by the mean-comparison test (t-test) and the results are all significant at 5% level. To save space, these p-values are not reported.

In Fig.4.8, we combine the ownership variables and industries to conduct the analysis. The investment efficiency of the industries from the secondary sectors is still in line with the previous findings. To be more specific, among different ownerships, the industry-level IEI is similar with the facts shown in table 4.6: private firms show highest level of IEI while the SOE firms show lowest; the collective firms perform better than foreign firms. However, the results of industries in tertiary sectors are interesting. First, in the consulting, research and marketing industry, the collective firms show even lower IEI than the SOE firms. This may because the predecessors of the majority of collective firms are small manufacturing companies with low productivity in the rural area, which implies that they are not experienced in such industries. Second, in the arts, entertainment and recreation industry, the foreign firms show higher IEI than private firms. This is not strange if we consider the observation years in our sample. After joining in the WTO in 2001, China allowed foreign investors to take part in some of the entertainment industries, and then, foreign firms played a dominate role in some sub-industries (e.g. film industry).

Fig.4.8 IEI comparison across industries and ownerships



	SOE	Private	Foreign	Collective
Arts, entertainment and recreation	0.257	0.324	0.348	0.327
IT and communication	0.255	0.351	0.311	0.338
Manufacturing	0.257	0.354	0.293	0.310
Entire sample	0.251	0.359	0.299	0.320
Construction	0.240	0.369	0.305	0.312
Power and water supply	0.234	0.365	0.300	0.330
Consulting, research and marketing	0.336	0.411	0.342	0.251
Administrative and support services	0.267	0.375	0.316	0.374

Note: each two mean values from different sample groups have been assessed by the mean-comparison test (t-test) and the results are all significant at 5% level. To save space, these p-values are not reported.

4.6 Conclusion

In this chapter, we first introduce the stochastic frontier approach to estimate measures of financial constraints among a panel of 66,500 Chinese private firms, for the 2000-2007 period. Then we conduct a post estimation analysis, using the investment efficiency index, which is calculated from the main regression results, to investigate whether the ownership, region and industry matter firms' financial constraint.

In the empirical regressions, the main findings are in accordance with the existing literature in firm-level investments, cash flows, assets and coverage ratio of firms alleviate financial constraints. The degree of financial constraint is higher for highly leveraged firms, indicating the leverage adversely affects the firms' financial constraint. These results are consistent with the literature of investigating the ICFS regarding both the Chinese listed and private firms.

Regarding the post estimation analysis, the findings are interesting. Firstly, for the entire samples, the investment efficiency distribution is roughly right-skewed, indicating the majority of firms show a significant level of financial constraint. Secondly, regarding the different ownerships, private firms show the highest efficiency while the SOE firms show the lowest efficiency, which is also in line with the existing literature. However, the foreign firms show a lower efficiency than the private and collective firms. Thirdly, in terms of the marketization factor, firms in regions with superior marketization show higher efficiency than their counterparts situated in provinces with inferior marketization. Fourth, in terms of industry factors, we find that industries in the tertiary sector show a relative higher efficiency than industries in the secondary sector. However, the secondary sectors show a more stable efficiency across years. Finally, some industries (e.g. arts, entertainment and recreation) in the tertiary sector displays different tendency of financial constraint, which may be affected by the firm ownerships.

The limitations for this paper are as follows. First, we do not have the market data, so we cannot make a comparison between the listed and private firms for the investment efficiency. Secondly, one assumption of the stochastic frontier approach is that no endogeneity exists in the model. So we cannot find the method, which is similar to the instrumental variable approach in the stylized research, to make further robustness test. Thirdly, although we have used two different ways to capture the investment opportunities, the methods we applied have some innate shortcomings. For instance, we argue the Fundamental Q should be forward looking, however, the calculation of FQ is based on the lagged variables.

Chapter 5 - Cash holdings and R&D smoothing: empirical evidence from Chinese listed manufacturing firms

5.1 Introduction

In the endogenous growth theory, the core factor of the key driver for the economic growth is research and development (Romer, 1990). Due to the successful application of "reform and opening up" policy in the past four decades, China has become one of the major economics in the global market. Based on economic growth, China's technology and innovation system has experienced remarkable changes and the R&D performance has improved significantly. According to OECD (2018), gross domestic spending on R&D in China increased consistently from 0.893% in 2000 to 2.108% in 2016. If we consider that the average growth rate of China's GDP is around 7% from 2000 onwards, the level of the innovation growth should be even more marvelous. In the meantime, the impressive growth on the R&D sector can be regarded as a signal of fruitful reform in the field of education. Moreover, the improving of legislation in the field of intellectual property rights also contributes to the success of the R&D growth.

However, the financial crisis triggered by the US subprime mortgage turmoil has adversely impacted the major economies and financial markets from 2007 onwards. Nevertheless, the innovation sector in China is unlikely to be impacted by the financial crisis. According to OECD (2018), the GDP on R&D in China increased gradually from 1.373% of GDP in 2000 to 2.108% of GDP in 2016. In terms of the firm level, the R&D expenditure ratio has been enhanced from 0.3% in 2007 to 2.2% in 2016 (see figure 5.2 in page 161). Therefore, a question has occurred: **how do the Chinese firms keep consistent innovation outlay?** This is an interesting question. On one side, firms have to be confronted with the external pressures such like the financial crisis. On the other side, the nature of R&D investment is long period, hardly reversible, and limited collateral value (Brown and Peterson, 2011). Hence, the information asymmetric problem of the R&D investments may incur the liquidity friction in the innovation projects.

In the meantime, one phenomenon we need to notice is that firms' cash holding level is increasing in the recent years, both for the firms in developed economics and in China. For example, for the US firms, cash and its equivalents was 21.6% of the total assets at the end of 2015, with the percentage increasing over recent years (Compustat, 2018). For Chinese firms, the average level of cash holding in the A-shares market has increased from 17.1% in 2007 to 21.3% in 2016. The figure implies that more than one fifth of the total assets are cash and its equivalents in Chinese firms. However, holding cash has a high level of opportunity costs. On one side, the profit rate on cash is much lower than that of other investments at the same risk level. On the other side, the managers could invest cash in investments with suboptimal efficiency to obtain personal benefits, while at the same time decrease shareholders' wealth (Jensen and Meckling, 1976). Therefore, another question occurs: **why do the firms hoard so much cash in spite of the opportunity costs?**

This chapter tries to connect the two questions above. One possible explanation is that cash holding may help firms invest in the R&D project persistently. To be more specific, in the presence of temporarily shocks, firms can use the cash holdings to smooth the R&D expenditure. The Ministry of Finance (MoF) in China (2007) has suggest that all the listed firms could set up a reserve funding dedicated for the R&D investment, since it is highly irreservable. To be more specific, the MoF suggests firms with R&D projects or future plans should plan and calculate the R&D funding in advance in order to ensure the reserve is sufficient. Following Brown et al. (2009) and Brown and Peterson (2011), we employ a reduced Euler equation model to investigate the relationship between the R&D investment and cash holding. In the meantime, we also consider the factors of source of funds, firm's productivity and ownership concertation. The estimation method is system GMM (Arellano & Bover 1995; Blundell & Bond 1998), which is commonly used in the estimation of panel data. The data is obtained from the China Stock Market Trading Database (CSMAR), including 23,122 observations from 3175 firms between the year 2007 and year 2016.

Using the data above, first, we find that the R&D investment is persistent, while its adjustment cost is a convex function, which is in line with the Brown and Peterson (2011). The change of cash holdings, which is regarded as a "smoothing channel", is negatively related to the R&D investment, implying that cash holding plays a smoothing role in the R&D investment in the presence of the temporary economic shock or short-term cash flow fluctuation. Regarding the source of funds, firms with R&D use both external and internal finance to support their R&D projects, which is also in accordance with the literature (Hall, 1992, Bond et al., 2005). In terms of the size, larger firm are likely to invest more in the

R&D. This is because larger firms are more likely to have more funds to invest in the R&D activity and they are more likely to access bank loans than the small firms (Guariglia and Liu, 2014). For firms with different type of ownerships, SoE firms are not significant in the changes of cash holding, meaning that they may not be relying on the smoothing channel during the innovation project. This is in line with the "soft budget constraint" benefit of the SoE firms (Allen et al., 2005). However, even the SoE firms need to access internal funds to support the innovation. In the augmented model with cash flow interaction, we find that higher level of cash flow will weaken the R&D investment smoothing mechanism. With respect to the firm's productivity, both high and low productive firms use the smoothing channel during the R&D investment. However, firms with high level of productivity are more sensitive to the changes in cash holding than that in lower productivity counterparts. This may be explained as the self-selection effect between the productivity and the R&D investment (Aw et al., 2008). In terms of the ownership structure, firms with lower level of the ownership concentration are more sensitive to Δcashholding than those with higher ownership concentration. Finally, we change some proxies of control variables and make further sample splits to conduct the robustness test. The results are generally consistent with the baseline results and hypotheses are all supported.

The remainder of this chapter is organized as follows. Section 5.2 is the literature review, including literature in cash holding and R&D investment. Section 5.3 introduces the model specification and estimation methodology. Section 5.4 briefly describes the data and summary statistics. Section 5.5 is the empirical results while the Section 5.6 presents the robustness tests. Section 5.7 is the concluding remarks.

5.2 Literature review

5.2.1 Cash holding of firm: precautionary saving

A firm's cash holdings can partially show its investment and financial decisions. If the firm can access a perfect capital market, it can raise funding for the investment opportunities for a fair price at any time. In that case, the firm has little or even no motivation for hoarding excess cash. In the meantime, firm may have precautionary motive for accumulating cash when the capital market is imperfect since financing opportunities are limited.

Opler et al. (1999) investigate the determinants of cash holdings of US firms and address three points: transaction cost, asymmetric information and agency costs in asset holdings, and the managerial agency costs. Opler et al. (1999) employs the manufacturing firms from Compustat annual files for the 1952-1994 period. The results implies that firms with strong growth opportunities, firms with riskier activities, and firms with smaller size hold more cash than others. Firms with opportunity to access the financial market, usually large firms or firms with good ratings, hold less cash than the counterparts. These results reveal that firm will hold cash guarantee that they can to keep investing when cash flow is in bottom and as an alternative source when the external funds are expensive.

Partially following Opler et al. (1999), Almedia et al. (2004) argue that financially constrained firms will have greater propensities to save cash out of their incremental cash flows to secure future financing compared to unconstrained firms. They use a sample of listed manufacturing firms from 1971 to 2000. The empirical results shows the constrained firms will hold more cash when their cash flow are higher, while the unconstrained firms will display no systematic patterns in cash-cash flow sensitivities. In addition, these authors also find that the financially constrained firms will retain more cash during the macroeconomic downturn, while the unconstrained counterparts will not.

Khurana et al. (2006) show that the sensitivity of cash holdings to cash flows decreases with financial development. Financial development supports economic growth since the development can ease firm's access to the external finance. Following Alemeida et al. (2004), this paper employ cash-cash flow sensitivity to measure the firms' ability to access the external finance. The paper uses 48,400 firm-year observations from 12,782 firms within 35 countries, covering the period 1994-2002. The empirical findings indicate that the constrained firms' holdings of liquid assets would increase when cash flows are higher, whilst the unconstrained firms show no systematic action. In addition, the cash-cash flow sensitivity decreases with a country's level of financial development. Firms in underdeveloped countries shows greater propensity to save cash for precaution. This is not surprising since the process of financial development would provide a better environment for firms accessing external finance.

Han and Qiu (2007) estimate the impact of cash flow volatility on the link between cash holdings and financial constraints. They extend the model in Almeida et al. (2004), expressing that the key point for the precautionary motivation in cash holdings is the limited ability to diversify the future cash flow uncertainty and the intertemporal trade-off between current and future investments. These authors uses a sample of public firms using the Compustat quarterly data from the period 1997 to 2002. The empirical results exhibit financially constrained firms increase cash holdings in response to an increase in cash flow volatility. In contrast, the cash holdings of financially unconstrained firm are not sensitive to cash flow volatility.

However, unconstrained firms do not do so since they may not exhibit that sensitivity. Denis and Sibilkov (2010) argue that cash holdings are more valuable for constrained firms since constrained firms hold more cash when they want to invest big projects when they confront costly external finance. Higher cash holdings enable the firm to undertake more valuable projects. Using a sample of 74,347 firm-year observations between 1985 and 2006, these authors find that the positive association between cash and value is stronger for financially constrained firms. In the baseline regression, the constrained firms show a greater coefficient on cash holdings than those in unconstrained firms. Moreover, they point out that greater cash holdings are positively associated with net investment for financially constrained firms, and this association is stronger for constrained firm than non-constrained firms.

Erel, Jang and Weisbach (2015) focus on changes in financial constraints of target firms in European M&As. The results suggest that target firms are indeed constrained prior to the acquisition, and that the constraints are lessened after the firms are acquired. Cash holdings decline by approximately 1.5% for an average target firm after being acquired. Furthermore, a significant decline is found in the sensitivity of investment to cash flow, with the magnitude of the post-acquisition sensitivity being less than half of that before the acquisition.

In the meantime, Almeida et al. (2004) argue that there should not be a systematic relationship between changes in firms' cash holdings and current cash flows for the unconstrained firms. However, the cash flow sensitivity of cash could not well capture the impact of financial constraints. For instance, McLean (2011) shows that US listed firms get their cash increasingly from newly issued shares rather than from cash flow operations. By using a large data sets including 140,711 firm-year observations from 1971-2008 in US, this paper exhibits a increasing trend in the savings of share issuance proceeds as cash, and this can be explained by the increasing precautionary motivation. Share issuance–cash savings varies with the cost of issuance, which is consistent with the hypothesis that firms only issue and save when costs are low. In addition, when the economy is expanding, increases in precautionary motives are strongly related to increases in share issuance–cash savings.

Compares with the literature listed above, Venkiteshwaran (2011) estimates a dynamic model that allows firms to adjust their cash holding levels over time and find evidence consistent with a trade-off type behavior in cash holding levels. According to Denis and Sibilkov (2010), for the constrained firms, the shareholder value consequences associated with deviating from optimal levels of liquid assets. Hence, it is important whether adjustment frictions can influence the cash holding decisions. This paper employs a large panel of U.S. manufacturing firms between 1987 and 2007 as a sample. The main finding is that firms with high levels of cash systematically reduce their cash holdings and that change in cash holdings display auto-regressive properties consistent with mean reversion of cash holding to targeted or optimal levels, and vice versa. In addition, cash holding levels for firms with excess cash persists over time compared to those that have an insufficient level of cash. Small firms typically hold excess cash and are quicker to correct deviations than large firms. This is in consistent with the view that it is more costly for financially constrained firms to operate at suboptimal levels of liquid assets.

5.2.2 Cash holding of firms: agency problem and corporate governance

In the listed firms, there is an agency problem between shareholders and managers. Due to separation of ownership and control, self-interested managers will seek to use corporate resources for their own benefit at the expense of shareholders' interests (Jensen & Meckling, 1976). For shareholders, the optimal cash policy is to invest in profitable projects and distribute the excess cash to them after all positive NPV investments have been made. However, the managers may hold excess cash for seeking their personal benefits, which will impair shareholders' value. Hence, one key question in this field is to determine the agency cost of retaining cash within the firms.

First, in terms of the corporate governance and the value of cash holdings, Opler et al. (1999) employ the US listed firms and show no evidence of a decrement in the value of cash holdings. However, using stock returns to value cash holdings, Dittmar and Mahrt-Smith (2007) investigate the importance of good corporate governance on cash holdings. The results firstly show the value of cash holding is substantially less if a firm has poor corporate governance. Secondly, poorly governed firms waste excess cash resources and thus destroy firm value. To be more specific, the firms with poor corporate governance usually waste their excess cash more quickly than those with good corporate governance on the less profitable investments. Furthermore, firms with acquisitions are also in compliance with these results. It is worth noting that the quality of corporate governance does not influence the decision to accumulate cash but influences the excess cash spending decisions.

Second, some research investigates the relationship between managerial stock ownership and the cash holdings. Based on the agency theory, the level of corporate cash holdings may reduce when the level of agency problem reduces. Empirically, Nikolov and Whited (2014) consider the effects of managerial compensation based on firm size, managerial private benefits from diverting liquid resources, and limited managerial ownership of the firm. The results prove that is one important reason of increased cash holdings is the low managerial ownership. Ozkan and Ozkan (2004) incorporates the ownership and board structure of firms into the analysis of cash holding decisions and examines the determinants by a sample of UK firms over the period 1984–1999. The empirical results reveal that firm’s cash holding starts to decrease when the managerial ownership increases to 24%, and then rises as managerial ownership increases to 64%. Finally, cash holdings fall again for managerial ownership levels above 64%. This research provides that there may not exist a monotonous relationship between cash holding and managerial ownership.

Third, the quality of corporate governance can also impact on the propensity of managers to spend excess cash. When a firm shows a poor quality of corporate governance, the managers are more likely to use excess cash to pursue their own benefits. Harford (1999) focuses on the merger and acquisition activities on cash-rich firms. The empirical results finds firms with high level of cash holdings are more likely to attempt corporate acquisitions. In addition, when they successfully complete an acquisition, the shareholder value is decreased. To be more specific, the empirical estimations show that the acquisitions destroy 7% of shareholders' value regarding the cash reserves. In addition, Opler et al. (1999) argue increments in cash accumulation are related to increment in acquisitions and to shareholders' payout. While this acquisition activity is consistent with the agency motive, the payout of excess cash is not.

5.2.3 Cash holding and firm's real decision

Liquidity management is at the heart of corporate policy. Hence, the level of cash holding may have implications for firms' real activities such as investment, employment, research and development (R&D), and mergers.

Klasa et al. (2009) investigate whether firms' cash holding policies are affected by strategic considerations that arise in the bargaining between the firm and its unionized workers. Using 34,142 firms during 1983-2005, they find a negative association between unionization and corporate cash holdings. This empirical result suggests that firms facing stronger unions strategically choose to hold less liquid assets to improve their bargaining position against organized labor. In addition, they find that increases in cash holdings raise the likelihood of a subsequent strike. This indicates that larger cash reserves weaken a firm's bargaining position because these reserves convey to unions that the firm is able to meet their demands.

Almedia et al. (2011) study the way in which acquisitions can reallocate liquidity across firms in a given industry. The authors propose a theory explaining why distressed firms could be acquired by relatively liquid firms, even in the absence of operational synergies. Their theory further examines how firms choose between cash and credit lines as the optimal source of liquidity to fund these transactions. The idea underlying this model is that acquirers in the same industry are in a privileged position to acquire their distressed targets because they can access some of the income of the target that is non-pledgeable to industry outsiders.

Fresard (2010) focuses on whether cash reserves can increase a firm's strategic aggressiveness. Using a variety of empirical identification strategies dealing with the endogeneity of firms' cash positions, this author concludes that firms with more cash than their rivals tend to gain market shares. This effect is robust to the inclusion of the debt effect discussed above and is more pronounced in industries in which the rival has a harder time getting access to external financing. In addition, competitive effect of cash contributes to an increase in firm value and operating performance.

Haushalter et al. (2007) consider the similar problem from the perspective of the way corporate policies adapt to industry conditions. By using a sample including S&P 500 manufacturing firms from 1993 to 1997, the empirical results show that product market considerations influence corporate cash and hedging policies in significant ways. In particular, the higher the risk of predation, the more the firm will save and hedge with derivatives. Overall, the corporate cash holdings and derivatives usage are equilibrium outcomes that are simultaneously determined by a firm's financing, investment, and product market environment.

Brown and Peterson (2011) concentrate on the relationship between cash holding level and firm's R&D investment smoothing. They believe that cash holdings buffer R&D from shocks to finance, thereby partially avoiding the high adjustment costs associated with altering the path of R&D investment. Using publicly traded firms in U.S. manufacturing over the time period 1970–2006, they find that, for young manufacturing firms, the path of R&D investment is far less volatile than key sources of finance and that firms appear to accomplish this smoothing by drawing down cash holdings when the availability of finance is low and building up cash reserves when finance is readily available. For firms relying on cash holdings to smooth R&D, the coefficient on the change in cash holdings should be negative, because reductions in cash free liquidity for R&D. In addition, these findings are significant for firms most likely to face financing constraints while there is no evidence for firms less likely to be financially constrained.

5.2.4 Cash holding in Chinese firms

China is a good laboratory for examining corporate cash holdings since the government or its agencies still retain a controlling or significant ownership stake in Chinese public listed companies.

In China, the State-owned firms or firms with high government ownership are subject to a ‘soft budget’ constraint, suffer the burden of pursuing social objectives and enjoy easier access to credit from state-owned banks (Lin and Tan, 1999). Therefore, these firms may hold low levels of cash. Megginson et al. (2014) reveals the relationship between state ownership and cash holdings in China’s share-issue privatized firms from 2000 to 2012. The paper reveals that the cash holding level increases as state ownership declines. For the average firm in the sample, 10% decline in state ownership leads to an increase of around RMB 55 million in cash holdings. This negative relation can be attributable to the soft-budget constraint impeded in state ownership. In terms of the non-SOE firms, they are difficult to obtain external finance from banks. Allen et al. (2005) argue that private firms still have more difficulty in gaining access to external finance compared to SOEs. Hence, in order to invest in future growth opportunities, companies controlled by private owners will have a higher optimal level of cash holding compared to a state controlled firms. However, in the case of family owned Chinese firms. Nevertheless, high levels of cash are used for tunneling at the expense of minority shareholders (Liu et al., 2015).

Corporate governance in Chinese firms can also reduce the agency problem. Chen et al. (2012) investigate the impact of corporate governance on 1,293 Chinese-listed non-financial firms observed between 2000 and 2008. The empirical results show that corporate governance reform resulted in the ratio of cash to non-cash assets falling from 23.5% to 20.8%. This also provides that the shareholding reform from 2005 improves corporate governance, which reduces self-interested managers' ability to save corporate cash for their personal benefit. In addition, this decrement is larger in privately controlled firms than state controlled firms.

Moreover, there is some research focusing on how the quality of political governance and institutional development can impact on firm’s cash holding. By using data on government quality from a World Bank survey including 120 major cities and 14,200 firms in China, Chen et al. (2014) report that an authority with a good quality of governance lowers the investment sensitivity to cash flows and the sensitivity of cash to cash flows, decreases cash holdings more significantly in private firms than in SOEs, and improves access to bank loans and trade credit financing. In addition, this paper also exhibits the negative relation between government quality and cash holdings reflects the interaction between the twin agency problems

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Kusnadi et al. (2015) estimate how institutional development and state ownership influence corporate cash holdings among Chinese firms. The empirical results illustrate that firms in provinces with more developed institutions (non-state-controlled firms) hold more (less) cash reserves than those in provinces with less developed institutions (state-controlled firms). Moreover, these authors also report the positive effect between institutional development and cash holdings is more prominent for non-state-controlled firms. They find too that the impact of institutional development on the cash holdings of non-state controlled firms is also attenuated as these firms become politically connected. This can be explained as political connections potentially mitigating the threat of political extraction for firms, especially the non-state controlled ones.

In terms of the motive for cash holding for Chinese firms, Guariglia and Yang (2016) find that it is more likely to be the precautionary savings. Using 1,478 listed firms in the period 1998-2010, they find that in line with most of the findings from US and European firms, firms in China behave consistently with the trade-off view. They also find evidence of imperfect and continuous rebalancing of cash holdings toward a target level, with average annual adjustment speeds ranging from 0.331 to 0.580. The values of the adjustment speeds also indicate that the typical Chinese listed firm completes half of its required cash adjustment in a period ranging between 1.2 and 2.1 years, which is longer than the corresponding period found for US and European firms. This suggests that Chinese firms rebalance their cash holdings slower than firms from the West, probably due to relatively higher adjustment costs.

5.2.5 Nature of R&D investment

Research and development is a general component of innovation activity. A firm's R&D activity often contains a large set of innovation projects, which are usually long period and hardly reversible. Hence, the discussion above reveals that the most important feature of the R&D investment is the high level of adjustment costs. Hall (1992) argues that the result of the innovation activities is generally regarded as a type of intangible asset, which cannot be treated as collateral. In addition, the features of R&D project are more expensive and uncertain than fixed investments. Hence, R&D investment is more likely to be constrained by the cash flow. This paper collects 2,500 US manufacturing firms from 1958 to 1987 and finds the access of debt for source of fund is positively related to the R&D investments. In addition, compared with the ordinary investment, the R&D investment is more sensitive to firm's liquidity. Mulkay et al. (2000) employs two similar samples from the US and French and confirms the finding of Hall (1992): the important of profit or cash flow in general investment and R&D are both confirmed in the US samples, but profit does not matter in French firms during 1982-93 period (Mulkay et al., 2000:24). Furthermore, the cash flow impact on the R&D is dramatically higher than that on fixed investment. For the transition economies, Guariglia and Liu (2014) use a sample of 120,000 unlisted Chinese firms and to investigate this relationship. The baseline specification is similar to the Euler equation used in Whited (1992) and Bond and Meghir (1994). Since only 13% of observations are likely reveal the innovation activity in the sample firms (Guariglia and Liu, 2014: 231), the estimation method is the Tobit model. Based on several specifications and estimation methods as robustness check, the result indicates that all kinds of Chinese firms' R&D investment are subject to the financial frictions, particularly the small firms and the private firms.

The second important feature of the R&D investment is that it is more prone to use the equity funds than debt finance. Compared with the fixed investment, the R&D investment is less likely to access the debt finance, since the information may be leaked when seeking external finance and therefore the value of innovation would be decreased (Bond et al., 2005). Another important reason is, for the bank and other type of the debt issuers, the borrowers usually need to pledge collateral to access the debt, especially for the risky borrowers. However, with the uncertainty output of the R&D investment, the R&D is regarded as a limited value of collateral (Berger and Udell, 1990). In terms of empirical evidence, Alderson and Betker (1996) investigate the relationship between liquidation costs and key proxies used to describe capital structure. These authors report a negative relationship between liquidation costs to fixed-to-total assets ratio. In the meantime, a positive relationship between liquidation costs and R&D expenditure is also reported.

Thirdly, the R&D investment is also associated with firm's productivity. Innovation activity is crucial but not essential for firms. Therefore, Aw et al. (2008) point out that there exists a self-selection channel for firms involved in R&D activities, i.e. only firms with high level of productivity can invest in R&D activities or adopt new technology. Aw et al. (2011) construct and estimate a structural model to further investigate the relationship among firm's productivity, export and R&D decisions. Using Taiwanese firms in the electronics industry between the years 2000 and 2004, these authors conclude that the underlying productivity evolves endogenously, which makes firma with high level productivity invest in both exporting activity and R&D investment. In addition, both the R&D and exports positively impact on the future productivity, which leads to the reinforcement of the self-selection effect.

Other than these studies above, some literature finds there is no relationship between cash flow sensitivity and R&D investment. Bond et al. (2005) employ the firm-level data from both UK and Germany during the period 1985-1994. They create an error-correction dynamic model and uses system GMM estimator to infer the relationship between cash flow and both fixed investment and R&D. The empirical analysis illustrates that fixed investment in UK samples is sensitive to the cash flow, nevertheless, in German firms it is not. In terms of the R&D investment, it is not sensitive in neither of the two countries. However, there does exist a significant correlation between cash flow and whether or not a firm performs R&D.

5.2.6 Ownership concertation and R&D investment

High quality of corporate governance is known to be a crucial factor which benefits macroeconomic growth and market development (OECD, 2004). However, Morck et al. (2002) point out that corporate control in many countries is not at the optimal level and this may impact the R&D outlay adversely. The corporate ownership structure is a part of the principal-agency theory. To be more specific, the core relationship between the principal and agent is on account of the convergence between the interests of managers and those of shareholders in the listed firms, as well as the conflicts in the concentrate ownerships between the majority and minority shareholders (Jensen and Meckling, 1976; La Porta, 1999; Faccio and Lang, 2002).

As discussed in the previous part, R&D investment is usually long period and hardly reversible. Given this condition, shareholders may be interested in investing in R&D, since they can have a stake in maximising value during a long-term investment. For corporate managers, they may have a different perspective for pursuing short time period profit maximization. Therefore, the R&D investment decisions are one of the issues to incur the principal-agency conflicts. To be more specific, Shleifer and Vishny (1989) argue that the shareholders may not assess the long-term innovation investment properly, since they may not have the corresponding knowledge or skills to evaluate the investment, or due to the companies may not release the full information to the shareholders. In terms of the managers, with the risky nature of the R&D projects, they may be concerned about the failure of the projects and choose low risk strategy to decline the innovation inputs.

In the empirical literature, the relationship between ownership concertation and R&D expenditure is in controversy. Using the US manufacturing firms, Francis and Smith (1995) examine the relationship between innovation outlay and the ownership structure. The paper has several different findings regarding the ownership concertation and R&D activities. On one side, in terms of the patent, firms with decentralized ownership structure are less innovative. The authors believe that concentrated ownership may do better in alleviating the agency costs during the R&D project. On the other side, although firms with more concentrated ownership have more output of patents, the empirical results also support the view that diffusely held firms can invest more in R&D projects than their counterparts with concentrated capital structure. Minnetti et al. (2012) test the effect of ownership on the R&D expenditure. The key finding is that concentrated ownership will adversely impact on the firm's innovation projects. In addition, they further point out that firms with more family ownership will support more R&D investments, especially in the decisions regarding innovation activities. Cebula and Rossi (2015) employ 369 firm-year observations from Italian firms between 2005 and 2013. The key finding is a negative relationship between ownership concentration and R&D expenditure. The main findings in these two recent papers are in contradiction to those of Francis and Smith (1995) which uses the US manufacturing datasets. The differences may implicitly show that the principal-agency problem in the US listed firms may differ from that in Europe and Asia, especially for the unlisted firms and companies with more family ownerships. Specifically, the findings from Minnetti et al. (2012) and Cebula and Rossi (2015) indicate that firms may choose a conservative operational strategy if they have a high level of ownership concentration.

Another strand of literature focuses on the institutional ownership and the R&D expenditure. For instance, Bushee (1998) finds the higher ratio of institutional ownership held in the firms, the less likelihood of managers cutting back the R&D project in the presence of earning shocks. Following Bushee (1998), Eng and Shackell (2001) employ US technology firms as a sample and find that institutional ownership has positive effects on the firm's R&D decisions and expenditures. This finding implies that the horizon of the institution investors may affect the manager's behaviour. Nevertheless, some literature points out that the institutional investors may prefer short-term profit to long-term performance. Therefore, the institutional ownership may be negatively associated with the firm's R&D investment and performance. Brossard et al. (2013) use the R&D expenditure as a proxy of firm' innovation activity and employ a large sample consisting of European innovative firms to investigate the relationship between the institutional ownership and R&D activities. The findings are partially in line with the papers discussed above: there is a positive association between the R&D investments and institutional investors. However, if the institutional investor is the one who is seeking short-term performance, the relationship between the innovation activities and the institutional ownership is negative.

5.2.7 Gaps and hypotheses

From the literature mentioned above, the mainstream reasons for firms hoarding cash are divided into two motives: precautionary savings and agency problems. In addition, the majority of the research papers listed above use firm-level data and explain the variations at micro level, too. However, the stylized facts show that, in the recent decades, there is a rapid increase in aggregate corporate cash holdings. For instance, from the 1990s to 2000s, the cash holdings of US firms more than doubled to about 13% of firms' total assets, which is approximately equal to 10% of annual US GDP (Dittmar & Mahrt-Smith, 2007). Moreover, Bates et al. (2009) illustrate, for US firms, cash holdings increasing by 0.46% per annum over the 1980–2006 periods. For the European firms, Ferreira and Vilela (2004) point out that they held 15% of their total assets in cash at the beginning of the 2000s. In terms of China, the cash ratio for listed firms is in a slowly increasing trend (see the figure 5.1). For all the firms issuing A-shares on either the Shanghai or Shenzhen stock exchange, this ratio increased from 12.3% in 2007 to 14.3% in 2016. It is not surprising that the cash holding ratio soared to 25.2% in 2010 because it should be the precautionary savings during the 2008-09 financial crisis.

In the meantime, it is widely known that the R&D investment is of high adjustment cost, and it is highly relevant to the financial frictions (Himmelberg and Peterson, 1994). Nevertheless, the R&D investment in Chinese firms is still increasing even in the financial crisis (see figure 5.2). Hence, firms should have an efficient method to manage a buffer stock of liquidity in order to maintain a relatively smooth path of R&D expenditure. One possible way is using the cash holding to smooth the R&D expense. As discussed above, Brown and Peterson (2011) employ the US manufacturing firms to find that cash holdings can smooth the R&D expenditure for small firms and firms with liquidity constraints. However, this is the only literature focusing on cash holding and R&D investment smoothing. Hence, we can further investigate the relationship between cash holding and R&D smoothing and will make contributions for the points below. First, to our best knowledge, this is the first research using Chinese listed firms as a sample to examine the relationship between cash holding and R&D expenditure smoothing. Unlike US firms, a large set of literature shows evidence that the firms in different ownership (i.e. SOE and non-SOE firms) will exhibit different behaviour since the SOE firms can benefit from the soft budget constraints. Hence, it is meaningful to further investigate whether the ownership can affect firms' liquidity management. Secondly, the existing literature regarding the relationship among the R&D, productivity and ownership concentration is mainly focusing on the samples in developed economics, such as the US and European firms. Specifically, the relationship between the R&D and the ownership concentration is different among regions. Therefore, it is worth investigating the relationship among these three factors by using a dataset from the largest developing country.

Based on discussions above we can introduce the hypotheses in this chapter, as below:

Hypothesis 5.1: The changes in cash holdings can smooth firm's R&D expenditure if there is a negative relationship between firm's cash holdings and R&D intensity.

Hypothesis 5.2: The non-SOE listed firms will show higher sensitivity in terms of cash holdings and R&D expenditure than that in SOE firms.

Hypothesis 5.3: The R&D smoothing effect will be weakened if firms have more cash flow.

Hypothesis 5.4: Firms with high level of productivity will show high sensitivity in the R&D smoothing channel than the firms with low level of productivity.

Hypothesis 5.5a: Firms with high level of ownership concentration will show high sensitivity in the R&D smoothing channel than the firms with low level of ownership concentration.

Hypothesis 5.5b: Firms with low level of ownership concentration will show high sensitivity in the R&D smoothing channel than the firms with high level of ownership concentration.

The two hypotheses are opposite. As shown in the section 5.2.6, the existing empirical literature shows controversy regarding the relationship between the decision of R&D investment and ownership. Therefore, we set two opposite hypotheses to explain the regression results in the section 5.5.

5.3 Methodology

In this part, we will employ a model, containing R&D expenditure, the change in cash holdings and a vector of firm characteristics, which may affect firms' investment demand and the level of financing constraint, to investigate whether the cash holdings can influence the firm's R&D activities.

5.3.1 Measurement of R&D smoothing

In the literature, there are two methods to measure R&D smoothing. One is from Acharya et al. (2007), while the other is from Brown and Peterson (2011). The method in Acharya et al. (2007) is to employ the correlation between a firm's cash flow and the median R&D expenditures at industry level to evaluate a firm's R&D smoothing. However, this is not eligible for Chinese listed firms since the data of industry-level R&D expenditure is not available. The measurement in Brown and Peterson (2011) is to use the correlation between a firm's R&D spending and its changes in cash holdings to evaluate a firm's R&D smoothing level. In fact, the method used by Brown and Peterson (2011) is a common one to evaluate firm's hedging needs which is widely used in the liquidity constraint literature (see Fazzari et al. (1988) as an example). Therefore, we will follow the method in Brown and Peterson (2011) to capture firm's R&D smoothing.

5.3.2 Model specification

This specification is based on the dynamic optimization "Euler equation" for imperfectly competitive firms that accumulate productive assets with a quadratic adjustment cost technology, which is first used by Bond and Meghir (1994). The advantage of this structural approach is that it controls for expectations. In terms of the empirical estimation, the Euler equation method eliminates terms in the solution to the optimization problem that depend on unobservable expectations (e.g. the shadow value of capital). In addition, it replaces expected values of observable variables with actual values plus an error orthogonal to predetermined instruments. Based on the model in Bond and Meghir (1994), Brown et al. (2009) extends this equation to estimate a dynamic R&D model with financial variables. Brown and Peterson (2011) further introduces the cash holding variables to directly investigate the use of cash accumulation for R&D smoothing. Therefore, the baseline specification is as follows:

$$RD_{it} = \alpha + \beta_1 RD_{i,t-1} + \beta_2 RD^2_{i,t-1} + \beta_3 \Delta CashHoldings_{i,t} + \beta_4 Q_{i,t} + \beta_5 Stkissues_{i,t} + \beta_6 CashFlow_{i,t} + \beta_7 Size_{i,t} + d_t + a_i + \varepsilon_{it} \tag{5.1}$$

Where:

RD_{it} denotes the R&D expenditure of the firm i in year t. The definition of the R&D expense in this chapter is the development cost in development process that is already capitalized but not yet transferred into intangible assets. Since firms issuing A-shares in China were asked to disclose such development costs in the annual reports from 2007 onwards, we directly collect the R&D data from the reports. The lagged R&D is expected to be positive and the value should be close to one, since the R&D is usually a long-term process, which should be highly persistent (Brown and Peterson, 2011). $RD^2_{i,t-1}$ is a quadratic term which may explain the non-linear effects from the lagged R&D spending. T he expected coefficient on the quadratic term is negative (Bond and Meghir, 1994; Brown and Peterson, 2011).

$\Delta CashHoldings_{i,t}$ denotes firm i's change in cash holdings in period t. As discussed above, this coefficient should be negative if a firm can benefit from smoothing the R&D expenditure with cash reserves. To be more specific, if the coefficient of the $\Delta CashHoldings_{i,t}$ is significantly smaller than zero, it implies that firms can smooth the R&D expenditure with cash reserves in the presence of the short-term cash flow shock. On the contrary, if the coefficient is not significant, it concludes that the process of R&D smoothing with cash holding does not exist.

$Q_{i,t}$ denotes the Tobin's Q value. This variable is applied to control firm's investment demands. To be more specific, Tobin's Q is widely used in the empirical research as a proxy of firm's long term investment opportunities (see Fazzari et al. (1988) and Chung and Pruit (1994) as example). The expected sign is positive, indicating that the increment of investment opportunities may have positive effect on the R&D investment.

$Stkissues_{i,t}$ is firm i's net stock issues in year t, while $CashFlow_{i,t}$ refers to a firm i's cash flow at time t. In the literature, the two financial variables are used to control the firm's level of financial constraints. For instance, Hall (1992) first points out that the R&D activity is sensitive to firm's liquidity. Mulkay et al. (2000) finds the cash flow impact on the R&D is dramatically higher than that in fixed investment. Meanwhile, the liquidity from issuing stocks should also be taken into account for the listed firms (Bond and Meghir, 1994; Brown et al., 2009; Brown and Peterson, 2011). The expected signs are both positive, because accessing the external finance or hoarding plenty of internal funds can alleviate the firm's financial constraint and then make a positive impact on the R&D expenditure.

$Size_{i,t}$ is a firm's total assets. Firms with smaller size and younger age are more likely to face information asymmetric problems, because of potential lenders cannot access information sufficiently from these firms (Petersen and Rajan, 1995). In terms of the empirical evidence, Hyytinen and Vaananen (2006) finds that the smaller and younger firms may face more severe information asymmetric problems than the larger and more mature counterparts in Finland. Using the Slovenian firms, Črnigoj and Verbič (2014) find that financial constraints impact more severe on the fixed investments in smaller firms. The significance of this variable shows firms may face the financial constraint, and *vice versa*.

d_t denotes the time specific effect which includes both time-variant determinants facing by each firm and the changes that could affect the R&D aggregate demand. a_i is the firm-specific effect, which controls all the time-invariant effects at firm level, for instance, industry level characteristics and technology level characteristics. ε_{it} is residual term.

The baseline model is employed to test the hypothesis 5.1 and 5.2. In order to test hypothesis 5.3, the baseline model can be extended as follows.

$$RD_{it} = \alpha + \beta_1 RD_{i,t-1} + \beta_2 RD^2_{i,t-1} + \beta_3 \Delta CashHoldings_{i,t} + \beta_4 Q_{i,t} + \beta_5 Stkissues_{i,t} + \beta_6 CashFlow_{i,t} + \beta_7 Size_{i,t} + \beta_8 CashFlow_{\mathrm{i,t}} \times \Delta CashHoldings_{i,t} + d_t + a_i + \varepsilon_{it} \quad (5.2)$$

As discussed in the literature review, the R&D investment is risker than that in fixed investment. Furthermore, the development activities are usually regarded as confidential issues for firms. Therefore, firms cannot access debt finance for the R&D investments due to the high-level risk and information asymmetries. Hall (2002) points out that the research-intensive firms are in lower levels of debt-to-assets ratios than their counterparts. In the meantime, Ughetto (2008) argues internal finance plays an important role in a firm's innovative activities. When firms have a higher level of cash, this usually implies that firms are less constrained than before. Hence, it is not essential for firms to hold a large portion of cash in order to smooth the R&D investment. Based on the discussions above, the interactions between cash flow and cash holdings in equation (5.2) are expected to be positive: i.e. a higher level of cash flow will weaken the R&D smoothing channel.

In order to test hypothesis 5.4, the baseline model can be extended as follows.

$$RD_{it} = \alpha + \beta_1 RD_{i,t-1} + \beta_2 RD_{i,t-1}^2 + \beta_3 \Delta CashHoldings_{i,t} + \beta_4 Q_{i,t} + \beta_5 Stkissues_{i,t} + \beta_6 CashFlow_{i,t} + \beta_7 Size_{i,t} + \beta_8 HITFP_{i,t} \times \Delta CashHoldings_{i,t} + \beta_9 LOWTFP_{i,t} \times \Delta CashHoldings_{i,t} + d_t + a_i + \varepsilon_{it} \quad (5.3)$$

As discussed in the literature review, Aw et al. (2008) argues that there is a selection effect between firm's productivity and the R&D investment: i.e. firms with higher level of productivity are more likely to invest in R&D activities. Moreover, the R&D investment will then affect firm's productivity in the future, which reinforces the selection effect above. Therefore, firms with high level of productivity may show a stronger link between the R&D expenditure and cash holdings than those with low level of productivity. In the equation (5.3), the $HITFP_{i,t}$(LOW$TFP_{i,t}$) is initially defined as a dummy variable equal to 1 if a firm i's total factor productivity (TFP thereafter) at time t is in the top (bottom) half of the distribution of the TFP of all firms operating in the same industry as firm i at time t, and 0 otherwise. In terms of the TFP's calculation, we follow the method in Levinsohn and Petrin (2003). The expected sign is negative.

In order to test the hypothesis 5.5, the baseline model can be extended as follows.

$$RD_{it} = \alpha + \beta_1 RD_{i,t-1} + \beta_2 RD_{i,t-1}^2 + \beta_3 \Delta CashHoldings_{i,t} + \beta_4 Q_{i,t} + \beta_5 Stkissues_{i,t} + \beta_6 CashFlow_{i,t} + \beta_7 Size_{i,t} + \beta_8 HIHHI_{i,t} \times \Delta CashHoldings_{i,t} + \beta_9 LOW\mathrm{HHI}_{i,t} \times \Delta CashHoldings_{i,t} + d_t + a_i + \varepsilon_{it} \quad (5.4)$$

In terms of the proxy of the ownership concertation, Cebula and Rossi (2015) use the ratio of shares held by the top 3 largest shareholders. Based on this method, we further calculate the Herfindahl-Hirschman Index (HHI) as the proxy of the ownership's concentration. In the equation (5.4), the $HIHHI_{i,t}$(LOW$HHI_{i,t}$) is initially defined as a dummy variable equal to 1 if firm i's HHI index at time t is in the top (bottom) half of the distribution of the HHI index of all firms operating in the same industry as firm i at time t, and 0 otherwise.

In the baseline model (5.1), we add $CashFlow_{i,t}$ to control the firm's potential financing constraints. However, the sample we use in this chapter is from the public traded firms of China, which are unlikely to face the liquidity constraints. China's stock market is not as efficient as those in the developed economics (Allen et al., 2007). Firstly, compared with the stock market, the banking institutions are the dominant part in China's financial system (Allen et al., 2005). Secondly, the stock prices and the behaviour of investors are not driven by the fundamental values of the firms themselves. Feng and Seasholes (2004) further find there is a high correlation between the buying and selling trades in China's stock market. Beltratti (2016) points out that the abnormal returns in China's stock market are generally from information leaks, not from the risk premium. Thirdly, as discussed in the literature, the R&D investment is generally in higher risk than that of the fixed investment. Finally, in our sample, firms with R&D expenditure are smaller than average (see table 5.2). Therefore, it is essential to use the investment-cash flow sensitivity model to test whether the R&D firms are financially constrained. Following Fazzari et al. (1988), the model can be expressed as follows:

$$I_{it} = \alpha_0 + \alpha_1 CashFlow_{i,t} + \alpha_2 Q_{i,t} + v_i + v_t + e_{jt} \quad (5.5)$$

Where I_{it} denotes the firm's fixed investment in the year t. If the R&D firms in the sample are financially constrained, the coefficient of $CashFlow_{i,t}$ should be significantly higher than zero.

When we test the hypothesis 1-4, the sample we use only includes the firms with R&D investment. However, this may lead to a sample selection bias. In that case, prior to test the hypothesis 1-4, it is essential to use a full sample to have a binary regression in order to confirm the response probability between the R&D investment and the main control variables. Therefore, we create a pooled probit model, which is written as follows:

$$P(RD\_Dummy_{it} = 1|Z_{it}) = \Phi[\gamma_0 + \gamma_1 \Delta CashHoldings_{i,t} + \gamma_2 Q_{i,t} + \gamma_3 Stkissues_{i,t} + \gamma_4 CashFlow_{i,t} + \gamma_5 Size_{i,t} + v_j + v_t + e_{it}] \quad (5.6)$$

Where:

P stands for outcome probability;

$\Phi(\cdot)$ denotes a normal cumulative distribution function of the error term which is assumed to lie between the range of 0 and 1, 0 < $\Phi(\cdot)$ < 1;

RD_Dummy_{it} is a dummy variable. It equals to 1 when the firm i has record in the development expenditure in year t and equals to 0 if no R&D expense occurs;

In the equation (5.6), if the expected sign of each coefficient should be the same as the corresponding coefficient in the equation (1), this implies that the sample selection bias may not exist.

For the probit model estimation, the initial value of the coefficients obtained are the predicted probabilities of belonging to one of the categories. Therefore, when we report results for a probit regression, we will display the partial derivatives of probability with respect to each independent variable Z_{kit}, which is known as marginal effects. Marginal effects indicate the slope of the expected change in the probability of the outcome when the independent variables are changed one at a time. For a specific independent variable's marginal effect, it can be calculated at the mean of particular variable keeping all other variables constant. The marginal effect of the pooled probit model can be given by:

$$\frac{\partial[P(RD\_Dummy_{it} = 1|Z_{i(t-1)})]}{\partial Z_{kit}} = \frac{\partial[E(RD\_Dummy_{it})]}{\partial Z_{kit}} = \frac{\partial[\Phi(\gamma' Z_{it})]}{\partial Z_{kit}} = \Phi(\gamma' Z_{it})\gamma_k \qquad (5.7)$$

Where Φ is the probability density function for a standard normal variables; and Z_k is a coefficient of a particular continuous variable from the probit model where k=1, 2, 3,.., n.

5.3.3 Estimation method

The equation (5.1)-(5.4) will be estimated with the system GMM estimator, which was developed for dynamic panel estimations by Arellano and Bover (1995) and Blundell and Bond (1998). This method jointly estimates a regression in differences with the regression in levels by using lagged levels as instruments for the regression in differences and lagged differences as instruments for the regression in levels. The system GMM estimator addresses the weak instrument problem that arises from using lagged levels of persistent explanatory variables as instruments for the regression in differences, but it does require an additional moment restriction to hold in the data: differences of the right-hand side variables in estimation equation must not be correlated with the firm-specific effect (Blundell and Bond, 1998).

We will treat all financial variables (including $\Delta CashHoldings$) as potentially endogenous and use lagged levels dated t-3 as instruments for the regression in differences, and lagged differences dated t-2 for the regression in levels. To assess instrument validity we will follow Arellano and Bond (1991) and report an m3 test for third-order autocorrelation in the first-differenced residuals, which, if present, could make the GMM estimator inconsistent, and a Hansen J-test applied for over-identifying restrictions.

5.4 Data and summary statistics

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 2007-2016, which is obtained from the China Stock Market Trading Database (CSMAR). The main reason for the start year of 2007 is because this is the first year for Chinese listed firms to disclose the research expense in the financial statements. Originally, there are 23,122 observations from 3,175 firms. We firstly drop observations with negative sales, total assets minus total fixed assets, total assets minus liquid assets. We then drop all the financial firms. Then 1% outliers of main regression variables are dropped. We have 6,973 observations left, with number of observations varying from a minimum of 457 in 2007 to a maximum of 851 in 2016. The definition of each variable can be found at table 5.1, while the summary statistics between the entire dataset and firms with R&D records can be seen in table 5.2.

Table 5.1 Variable definitions

Name	Descripiction	Definitation
RD	Development expenses	Development expenses divided by operating revenue
cashholding	Cash holdings ratio	Cash and cash equivalents divided by total assets.
Δcashholdings	Changes in cashholdings	Net increase of cash and cash equivalents divided by total assets
Q	Tobin's Q	Total market value divided by total assets
stkissues	Proceeds from issue shares	The cash received from the issuance of stocks divided by total assets
cash flow	Cash flow	Net cash flow from operating activities divided by total assets
size	firm’s total assets	The sum of all assets of the firm. Shown in the logarithm.
HHI	concentration of ownership	The sum of squares of the share ratio holding by the largest three shareholders.
TFP	Total factor productivity	Calculated by the method in Levinsohn and Petrin (2003).

Table 5.2 Summary statistics for entire sample and firms with R&D records

Variables	Entire sample		Firms with RD		P-value
	mean	St.Dev.	mean	St.Dev.	
RD	0.004	0.032	0.019	0.053	0.000
cashholdings	0.131	0.185	0.182	0.248	0.002
Δcashholdings	0.012	0.138	0.028	0.232	0.003
Q	5.365	5.313	2.702	2.391	0.000
stkissues	0.054	0.091	0.066	0.001	0.000
TFP	0.047	0.053	0.055	0.080	0.000
cash flow	0.031	0.001	0.036	0.038	0.256
size	21.336	1.550	20.985	1.305	0.094
HHI	0.208	0.167	0.185	0.140	0.000
Obs.	23122		6973		

Note: the P-value is from the two-sample t-test with equal variances.

From table 5.2, we can find that the average R&D expense ratio is 0.004, while it is 0.019 for samples with R&D expense. In terms of the cash holding level, the R&D firms show a significant higher ratio (0.182) than the entire sample (0.131). This implies that the R&D firms may accumulate cash for smoothing the R&D investment in the presence of cash flow shocks. For the changes in cash holding, the ratio in R&D firms (0.028) is still higher than that in the entire sample (0.012). For the Tobin's Q, the entire sample is about two times higher than the R&D firms, indicating that the R&D investment may lower the market value of the firms. In terms of the stock issue ratio, the R&D firms show a slightly higher level (0.066) than the entire sample (0.054). However, the low level of this ratio implies issuing stocks may not be the primary source of external finance for Chinese listed firms. The R&D firms' TFP is 5.5%, which is higher than the entire sample (4.7%). In light of Aw et al. (2008), this implies a potential self-selection effect between the productivity and the R&D investment. In terms of firm's size, the firms with R&D expenditure (20.985) are slightly smaller than the average level (21.336), and this result is only significant at 10% level. Regarding the concentration of ownership (HHI), the R&D firms show a lower concentration (0.185) than the entire sample (0.208). This may implicitly support hypothesis 5b, which states that firms with diffusely held equity structure may be more likely to show high sensitivity to the R&D smooth channel.

Table 5.3 Summary statistics by different ownerships

Variables	SoE firms		Non-SoE firms		P-value
	mean	St.Dev.	mean	St.Dev.	
RD	0.011	0.001	0.026	0.001	0.000
cashholdings	0.143	0.003	0.213	0.007	0.000
Δcashholdings	0.018	0.002	0.036	0.006	0.008
Q	1.902	0.041	3.342	0.057	0.000
stkissues	0.032	0.002	0.094	0.004	0.000
TFP	0.052	0.043	0.057	0.046	0.001
cash flow	0.038	0.001	0.032	0.005	0.321
size	25.337	1.526	17.984	1.475	0.000
HHI	0.191	0.115	0.169	0.096	0.000
Obs.	2963		3611		

Note: the P-value is from the two-sample t-test with equal variances.

Table 5.3 reports the statistics of key variables between the SoE and non-SoE firms. Compared with the SoE firms, the non-SoE firms have more than double the R&D spending and around 50% more cash holdings. The Tobin's Q for non-SoE firms is also significantly higher than that in the SoE firms, so this can be used to explain why the non-SoE firms (0.094 in stkissues) are more likely to use equity market as the source of external finance than the SoE firms (0.032 in stkissues). In terms of the TFP level, the non-SOE firms are slightly higher than the SoE counterparts. For cash flow ratio, the reported p-value implies there may be no difference between the SoE and non-SoE firms. The non-SoE firms are generally smaller than the SoE firms regarding the level of total assets. In terms of the ownership concentration level (HHI), the non-SoE R&D firms are more decentralized than the SoE firms. From the key variables reported in table 5.3, it can be found although they can access the equity finance, the SoE listed firms may also benefit from the soft budget constraints.

Fig.5.1 Cash holdings by years

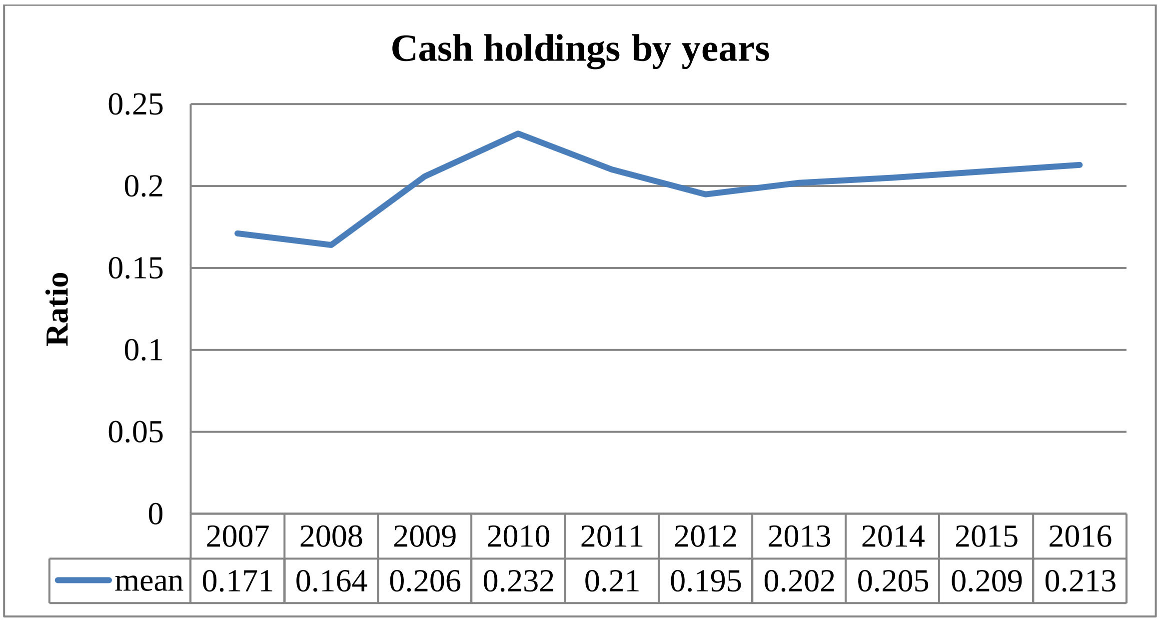

Fig 5.2 R&D expense by years

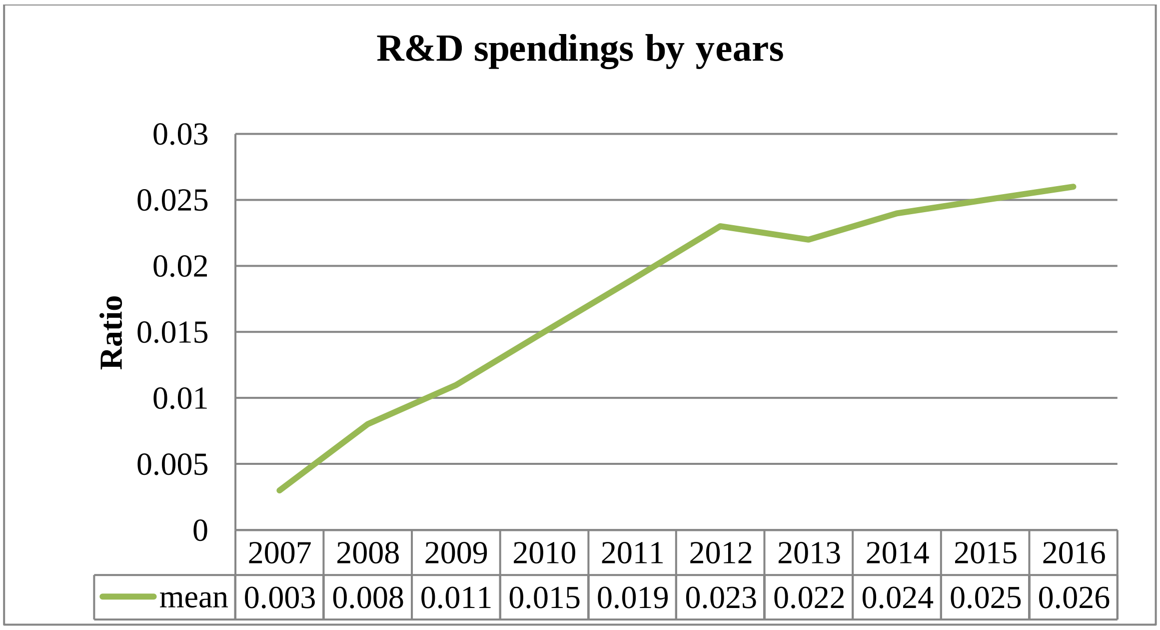

Fig. 5.1 and 5.2 shows the sample's cash holdings and R&D spending by firm years. From fig. 5.1, we can find that the cash ratio for the sample firms is in a slowly increasing trend after 2012. For all the firms issuing A-shares in either Shanghai or Shenzhen stock exchange, this ratio increased from 17.1% in 2007 to 21.3% in 2016. It is not surprising that the cash holding ratio soared to 23.2% in 2010 because it should be the precautionary savings during the 2008-09 financial crisis. In addition, we can see that the cash reserves are sharply increased during 2009-2010 period. We can guess this is caused by the financial crisis, which make the firms increase their cash holdings for precautionary saving. Hence, this can be regarded as an explanation for the set of dummy variable $Crisis_{\mathrm{i,t}}$ in the methodology section. In Fig. 5.2, when we examine the R&D expense during the period 2007-2016 (the R&D expense is disclosed since 2007), we would be surprised that the R&D investment is not affected by the external shock (i.e. financial crisis) . From Fig. 5.2, we can find that the R&D ratio is in an increasing trend. For all the firms with complete disclosure of R&D costs, the ratio increases from 0.3% in 2007 to 2.6% in 2017. The feature of the trend of R&D spending implies that cash holdings may be a source of finance to support the R&D activities during the financial crisis.

5.5 Empirical results

5.5.1 Stylized facts

5.5.1.1 Investment-cash flow sensitivity of the R&D firms

In order to test whether the sample firms with innovation expenditure are financially constrained or not, we follow the Fazzari et al. (1988) to investigate the relationship between a firm's fixed investment and cash flow. The regression results are reported in table 5.4.

Table 5.4 Results of investment-cash flow sensitivity

Dependent Variable: I_{it}	Entire RD sample
$CashFlow_{i,t}$	0.097***
	(0.035)
$Q_{i,t}$	0.0004***
	(0.000)
m1	0
m3	0.227
J-test (p-value)	0.013
Observations	5945

Note: Figures in parentheses are standard errors. J-test is Hansen test for over-identification, while m1 and m3 are the test of first and third serial correlation in the first-differenced residuals. Time dummies and industry dummies were included in the specification.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

From table 5.4, it can be seen that the key independent variable, $CashFlow_{i,t}$, is significant at 1% level. The value of coefficient 0.097 implies that the firm's fixed investment will increase 0.097% when the cash flow has 1% increment. Compared with the level of financial constraint in the literature related to Chinese markets (see Ding et al. (2013) as an example), the level of the R&D firms is low. However, this regression confirms that the financial constraints do exist in the listed firms with R&D expenditure.

5.5.1.2 Response probability between the R&D investment and the main control variables

In order to avoid the potential sample selection bias in the GMM estimation, we estimate the equation (4) and (5) to test the response probability between the R&D investment and the main control variables. The marginal effects are reported in the following table 5.5.

Table 5.5 Probit model estimation

Dependent Variable: RD_Dummy_{it}	Marginal values
$\Delta CashHoldings_{i,t}$	-0.037***
	(0.111)
$Q_{i,t}$	0.001***
	(0.001)
$Stkissues_{i,t}$	0.003**
	(0.007)
$CashFlow_{i,t}$	0.003**
	(0.0072)
Observations	19988

Note: The predicted probabilities reported are marginal effects calculated as equation (5.7). The figures reported in parentheses are asymptotic standard errors. Time dummies and industry dummies were included in the specification.

* indicates significant at 10% level.

** indicates significant at 5% level.

*** indicates significant at 1% level.

The sample used in the table 5.5 is the entire sample, including firms with and without R&D expenditure. From the table 5.5, we can see all the marginal values of coefficient are significant, and the signs are in line with the assumptions in the methodology section. To be more specific, the value of -0.037 in $\Delta CashHoldings_{i,t}$ can be interpreted that once the firm's change in cash holding decrease 1% in the year t, the firm will increase 3.7% to invest in the R&D activity. For $Q_{i,t}$, when the firm's Q increase 1%, the possibility of firm entering the R&D investment will increase 0.1%. The marginal of $Stkissues_{i,t}$ and $CashFlow_{i,t}$ are both at 0.3% level. The results from the probit regression indicates there may not exist the selection bias in the sample with R&D expense records.

5.5.2 Results from GMM estimation

Table 5.6 Baseline results and sample with different ownerships

Dependent Variable: RD_{it}	Entire RD sample (1)	SoE firms (2)	Non-SoE firms (3)	p-value
$RD_{i,t-1}$	0.865***	1.090***	0.792***	0.000
	(0.049)	(0.167)	(0.243)	
$RD_{i,t-1}^{2}$	-1.104***	-1.062***	-0.768***	0.0002
	(0.032)	(0.040)	(0.031)	
$\Delta CashHoldings_{i,t}$	-0.002***	0.008	-0.010***	0.0075
	(0.0003)	(0.022)	(0.001)	
$Q_{i,t}$	1.09e-7	0.00028	0.00027	0.581
	(2.93e-7)	(0.0003)	(0.0003)	
$Stkissues_{i,t}$	0.007**	0.009**	0.007**	0.072
	(0.003)	(0.003)	(0.003)	
$CashFlow_{i,t}$	0.004***	0.003**	0.004***	0.248
	(0.0018)	(0.0015)	(0.000)	
$Size_{i,t}$	0.002***	0.001	0.003***	0.0003
	(0.000)	(0.134)	(0.000)	
m1	0.033	0.017	0.024	
m3	0.867	0.598	0.957	
J-test (p-value)	0	0.004	0	
Observations	5945	2644	2968	

Note: Column (1) (2) (3) are the estimation results of equation (5.1) by a system GMM estimator. Industry and time dummies are included in the regressions. The instrument sets are all the independent variables lagged 3 times for the first difference equation and twice lagged for the level equation. Figures in parentheses are standard errors. J-test is Hansen test for over-identification, while m1 and m3 are the test of first and third serial correlation in the first-differenced residuals. The p-value refers to a test of the null hypothesis that the values of the coefficients from different samples are equal.

Table 5.6 shows the regression results using the system GMM estimation of equation (1). In the first differenced equation regression, the instrument used is all the regressors lagged three times. In the level equation regression, the instruments are the variables lagged by twice. Industry dummies and time dummies are also included.

Column (1) reports the estimation results of the entire sample firms with R&D investment records. We employ $RD_{i,t-1}$ to show that the R&D investment is persistent. The coefficient is 0.865, which is close to 1, implying that the 1% increment of R&D investment in the year t-1 will result in 0.865% increment of the R&D expenditure in the year t. According to Brown et al. (2009) and Brown and Peterson (2011), the quadratic term $RD_{i,t-1}^{2}$ is used to capture the relationship between the R&D investment and its adjustment cost. The negative coefficient of the $RD_{i,t-1}^{2}$ implies the R&D adjustment cost is a convex function of the R&D investment, which is in line with the literature. The $\Delta CashHoldings_{i,t}$, which is regarded as the "smoothing coefficient", is the key independent variable in this model. The value is -0.002 and is significant at 1% level. This can be interpreted in that the 1% decrease of the changes in cash holding will lead to 0.002% increase in the R&D expenditure. This suggests that the cash holding plays a smoothing role in the R&D investment in the presence of the temporary economic shock or short-term cash flow fluctuation. In terms of the Tobin's Q, the value of the coefficient is very small and not significant. For the $Stkissues_{i,t}$, the coefficient is significant at 5% level, showing accessing the external finance (by issuing stocks) can simulate firms in investing in the R&D. The value of $Stkissues_{i,t}$ can also partially explain the coefficient of the Tobin's Q: the effect of the Q would be partially diluted by the net value of new shares issuance. Regarding the cash flow, the coefficient in the baseline model is significant, indicating the positive relationship between the cash flow and firm's R&D investment. This finding is also in accordance with the literature in the R&D investment (e.g. Hall (1992), Mulkay (2000), Bond et al. (2005)). For the size factor, the value of the entire sample is 0.003 and significant at 1% level, implying that larger firm is likely to invest more in the R&D. This is in line with the Czarnitzki and Hottenrott (2011) and Guariglia and Liu (2014) who find that larger firms are more likely to have more funds to invest in the R&D activity and they are more likely to access the bank loans than the small firms.

Column (2) and (3) are the results of the equation (5.1) by using different sub-samples. The column (2) is the results from the SoE firms while the results of non-SoE firms are reported in the column (3). In terms of the persistence of R&D investment, the SoE firms show higher persistence (1.09) than the non-SoE counterparts (0.792). However, for the key explanatory variable, the changes in cash holding, the non-SoE firms show a higher level (-0.01) than the entire sample (-0.002), expressing that the non-SoE firms may more rely on the R&D smoothing mechanism. The SoE sample shows no significance in the $\Delta CashHoldings_{i,t}$ coefficient. This can be explained as the effects of the "soft budget constraint" (Allen et al., 2005). Regarding the Tobin's Q, the p-value suggests there is no significant difference among the three samples. Since the $Stkissues_{i,t}$ in both SoE and non-SoE firms are significant, this may also be because of the dilution effect from the stock issuance. For the cash flow coefficient, both of the samples are significant and there is no significant difference among the three groups. This is interesting since it implies that even the R&D investment in the SoE firms can be benefit from the increment in cash flow. The significance of the cash flow in both samples may further indicate that the R&D investment is risky, even the SoE firms need to access internal funds to support the innovation.

Table 5.7 Baseline mode augmented with the cash flow interaction

Dependent Variable: RD_{it}	Entire RD sample (4)
$RD_{i,t-1}$	0.891**
	(0.033)
$RD^2_{i,t-1}$	-1.032***
	(0.030)
$\Delta CashHoldings_{i,t}$	-0.003***
	(0.000)
$Q_{i,t}$	0.0001
	(0.001)
$Stkissues_{i,t}$	0.007**
	(0.003)
$CashFlow_{i,t}$	0.004***
	(0.0018)
$Size_{i,t}$	0.002**
	(0.001)
$CashFlow_{\mathrm{i,t}} \times \Delta CashHoldings_{i,t}$	0.003***
	(0.000)
m1	0.015
m3	0.544
J-test (p-value)	0.001
Observations	5945

Note: Column (4) is the estimation results of equation (5.2) by a system GMM estimator. Industry and time dummies are included in the regressions. The instrument sets are all the independent variables lagged 3 times for the first difference equation and twice lagged for the level equation. Figures in parentheses are standard errors. J-test is Hansen test for over-identification, while m1 and m3 are the test of first and third serial correlation in the first-differenced residuals.

Table 5.7 displays the estimation results using the system GMM estimation of equation (5.2). The results in column (4) show that the model is identified and all independent variables except the Tobin's Q are significant at 5% level or less. In this augmented model, we are focusing at the interaction term, $CashFlow_{\mathrm{i,t}} \times \Delta CashHoldings_{i,t}$. The value of the coefficient is 0.003. In the meantime, the coefficient of the $\Delta CashHoldings_{i,t}$ is -0.0003 and the $CashFlow_{i,t}$ is 0.004. Therefore, based on the three coefficients, we can infer that the positive sign of coefficient of the $CashFlow_{\mathrm{i,t}} \times \Delta CashHoldings_{i,t}$ shows higher cash flow will weaken the R&D investment smoothing mechanism. This is because the high level of cash flow indicates the firm may not be financially constraint. Therefore, they do not need to use the cash holdings to smooth the R&D investment.

Table 5.8 Baseline mode augmented with the TFP dummy interaction

Dependent Variable: RD_{it}	Entire RD sample (5)
$RD_{i,t-1}$	0.875**
	(0.412)
$RD^2_{i,t-1}$	-0.964***
	(0.311)
$\Delta CashHoldings_{i,t}$	-0.003***
	(0.0002)
$Q_{i,t}$	1.31e-8
	(3.26e-6)
$Stkissues_{i,t}$	0.006**
	(0.00298)
$CashFlow_{i,t}$	0.004***
	(0.0016)
$Size_{i,t}$	0.0022***
	(0.000)
$HITFP_{i,t} \times \Delta CashHoldings_{i,t}$	-0.011**
	(0.0049)
$LOWTFP_{i,t} \times \Delta CashHoldings_{i,t}$	-0.0002***
	(0.000)
m1	0
m3	0.313
J-test (p-value)	0.026
Observations	5945

Note: Column (5) is the estimation results of equation (5.3) by a system GMM estimator. Industry and time dummies are included in the regressions. The instrument sets are all the independent variables lagged 3 times for the first difference equation and twice lagged for the level equation. Figures in parentheses are standard errors. J-test is Hansen test for over-identification, while m1 and m3 are the test of first and third serial correlation in the first-differenced residuals.

Table 5.8 reports the results employing the system GMM estimation of equation (5.3). First, the values of coefficients expect Tobin's Q in column (5) are all significant at the 5% level or less. It implies that the model is identified properly. In this model, the key independent variables are the $\Delta CashHoldings_{i,t}$ and its two interaction terms with the TFP dummies. The coefficient of $HITFP_{i,t} \times \Delta CashHoldings_{i,t}$ is -0.0011, which is dramatically higher than the coefficient of $LOWTFP_{i,t} \times \Delta CashHoldings_{i,t}$ (-0.0002). This suggests that although all the firms with R&D investments use the smoothing channel, however, the R&D investment in firms with high level of productivity is more sensitive to that in lower productivity firms. This finding is in line with Aw et al. (2008). Therefore, this can be partially explained as the self-selection effect between the productivity and the R&D investment: i.e. the more productive firms are more likely to invest in R&D. Hence, these firms may more rely on the smoothing channel than their low productive counterparts.

Table 5.9 Baseline model augmented with the HHI dummy interaction

Dependent Variable: RD_{it}	Entire RD sample (6)
$RD_{i,t-1}$	0.794**
	(0.312)
$RD^2_{i,t-1}$	-1.032***
	(0.297)
$\Delta CashHoldings_{i,t}$	-0.0033***
	(0.000)
$Q_{i,t}$	1.27e-7
	(5.16e-6)
$Stkissues_{i,t}$	0.007**
	(0.003)
$CashFlow_{i,t}$	0.004***
	(0.0014)
$Size_{i,t}$	0.0031***
	(0.000)
$HIHHI_{i,t} \times \Delta CashHoldings_{i,t}$	-0.0014***
	(0.0003)
$LOWHHI_{i,t} \times \Delta CashHoldings_{i,t}$	-0.0061***
	(0.000)
m1	0
m3	0.146
J-test (p-value)	0.011
Observations	5945

Note: Column (5) is the estimation results of equation (5.3) by a system GMM estimator. Industry and time dummies are included in the regressions. The instrument sets are all the independent variables lagged 3 times for the first difference equation and twice lagged for the level equation. Figures in parentheses are standard errors. J-test is Hansen test for over-identification, while m1 and m3 are the test of first and third serial correlation, respectively, in the first-differenced residuals.

Table 5.9 is the results from estimation of equation (4). Firstly, like the results shown in the previous tables, the values of all coefficients, expect for Tobin's Q, are all significant at the 5% level or less. This implies that the model is identified properly. In this model, the key independent variables are the $\Delta CashHoldings_{i,t}$ and its two interaction terms with the HHI dummies. The coefficient of $HIHHI_{i,t} \times \Delta CashHoldings_{i,t}$ is -0.0014, significantly lower than the coefficient of $LOWHHI_{i,t} \times \Delta CashHoldings_{i,t}$ (-0.0061). The results reveal that, although all the firms with R&D investments use the smoothing channel, the R&D investment in firms with lower level of the ownership concentration is more sensitive to that of higher ownership concertation firms. Our findings are in line with those of Minnetti et al. (2012) and Cebula and Rossi (2015), revealing that listed firms with centralized capital structure in China may operate more conservatively than their counterparts. In addition, the results support the view that firms with diffusely held ownership show more persistence than the concentrated ownership firms in the R&D expenditure.

5.6 Robustness tests

In this section, we will run some robustness regressions to justify the empirical results shown in section 5.5. Firstly, we will change the proxies of some independent variables to test the all the hypotheses. Secondly, we will further split the sample to test the main hypothesis.

5.6.1 Alternative specification of the control variables

In terms of the alternative specifications, we replace the ΔCashHoldings, Q, productivity and the ownership concertation. For the ΔCashHoldings factor, we change the proxy from its original value to the log value. Then we replace Tobin's Q to the sales growth. Sales growth can reflect the firm ability to growth. Bond et al. (2005) points out that compared with the Tobin's Q, sales growth can rectify the mismeasurement of the investment opportunity to some extent. With respect to the productivity, we change the proxy from TFP calculated by Levinsohn and Petrin (2003) method to the Giannetti et al. (2015), which provides a method to compute TFP of Chinese listed firms. Regarding the ownership concertation, we first expand the ratio of shares from holdings by the top 3 largest shareholders to the holdings by the top 5 largest shareholders.

Table 5.10 using alternative independent variable for the baseline and augmented models

Dependent Variable: RD_{it}	Eq.(1)Entire sample	Eq.(1)SoE firms	Eq.(1)Non-SoE firms	Eq.(2)	Eq.(3)	Eq.(4)
	Column(1)	Column(2)	Column(3)	Column(4)	Column5)	Column(6)
$RD_{i,t-1}$	0.877***	1.114***	0.828***	0.909***	0.992***	0.816***
	(0.205)	(0.167)	(0.243)	(0.005)	(0.000)	(0.003)
$RD^2_{i,t-1}$	-0.913***	-0.639***	-1.002 ***	-0.988***	-1.117***	-1.106***
	(0.098)	(0.011)	(0.022)	(0.011)	(0.205)	(0.332)
$\Delta CashHoldings_{i,t}$	-0.047***	0.009	-0.089***	-0.061**	-0.051***	-0.042***
	(0.003)	(0.335)	(0.016)	(0.030)	(0.004)	(0.002)
$SalesGrowth_{i,t}$	0.0032	0.0028	0.0027	0.001	0.006	0.0032
	(0.041)	(0.0031)	(0.003)	(0.016)	(0.024)	(0.044)
$Stkissues_{i,t}$	0.011*	0.008**	0.005***	0.007**	0.004***	0.007***
	(0.006)	(0.002)	(0.000)	(0.003)	(0.000)	(0.000)
$CashFlow_{i,t}$	0.004***	0.0031**	0.004***	0.005***	0.011***	0.002***
	(0.0008)	(0.0015)	(0.000)	(0.0004)	(0.0008)	(0.000)
$Size_{i,t}$	0.005***	0.0012	0.0027***	0.002**	0.0025***	0.0027***
	(0.0013)	(0.162)	(0.000)	(0.001)	(0.00003)	(0.0002)
$CashFlow_{i,t} \times \Delta CashHoldings_{i,t}$				0.045***		
				(0.001)		
$HITFP_{i,t} \times \Delta CashHoldings_{i,t}$					-0.076***	
					(0.002)	
$LOWTFP_{i,t} \times \Delta CashHoldings_{i,t}$					-0.033***	
					(0.000)	
$HIHHI_{i,t} \times \Delta CashHoldings_{i,t}$						-0.029***
						(0.0047)

Table 5.10 using alternative independent variable for the baseline and augmented models(continued)

Dependent Variable: RD_{it}	Column(1)	Column(2)	Column(3)	Column(4)	Column5)	Column(6)
$LOWHHI_{i,t} \times \Delta CashHoldings_{i,t}$						-0.055***
						(0.000)
m1	0.002	0	0.024	0	0	0.006
m3	0.221	0.325	0.702	0.541	0.334	0.847
J-test (p-value)	0.005	0.016	0.027	0.016	0.006	0.024
Observations	5945	2963	3611	5945	5945	5945

Note: All the columns are the estimation results by system GMM estimator. Industry and time dummies are included in the regressions. The instrument sets are all the independent variables lagged 3 times for the first difference equation and twice lagged for the level equation. Figures in parentheses are standard errors. J-test is Hansen test for over-identification, while m1 and m3 are the test of first and third serial correlation, respectively, in the first-differenced residuals.

Table 5.10 expresses the results for all the hypotheses except hypothesis 2. Comparing the results shown in table 5.6 to table 5.9, it can be seen that regression results from the robustness specifications are generally consistent with the original results. To be more specific, results from the baseline model show that the value of $\Delta CashHoldings_{i,t}$ is -0.047 and is significant at 1% level. Since the proxy of the $\Delta CashHoldings_{i,t}$ is shown as log value, the coefficiient can be explained as once 1% decrease of the changes in cash holding will lead to 0.00047% increase in the R&D expenditure. The value of $\Delta CashHoldings_{i,t}$ in the SoE group is not significant, which further confirms that the SoE firms may benefit from the soft budget constraint. Similar to the results in table 5.6, the value of $\Delta CashHoldings_{i,t}$ in the non-SoE group is still at a high level (-0.089). In the column (4), the value of the interaction between the ΔCashHoldings and cash flow is negative, implying that this term is properly identified. Column (5) is the estimation of model augmented with productivity. Compared with their low-productive counterparts, 1% decrease of the changes in cash holding will lead to 0.00043% more increment in the R&D outlay in firms with high level of productivity. The difference of values between diffusely held and concentrated firms in column (6) again support the hypothesis 5b, showing that decentralized ownership firms can take advantage of using the smoothing channel in the R&D project.

5.6.2 Sample splits

In the empirical results section, the coefficient of cash flow and size implicitly suggests that firm's R&D expenditure is slightly financially constrained. Therefore, following the finance literature, we will split the sample by two criteria: the payout ratio and the firm size. For the payout ratio, according to Fazzari et al. (1988), firms with no dividend payout are more likely to be financially constrained than their counterparts. In terms of the size factor, we split the firms into large and small size firms based on the total assets. Since the size factor has been augmented in the baseline model, it will be removed in the regressions for the size split sub-samples.

Table 5.11 Baseline model with alternative sample splits

Dependent Variable: RD_{it}	Dividend payout			Firm size by total assets		
	no payout	positive payout	p-value	small group	large group	p-value
$RD_{i,t-1}$	1.090***	0.564***	0.000	0.687***	0.648***	0.000
	(0.098)	(0.013)		(0.155)	(0.211)	
$RD^2_{i,t-1}$	-0.306***	-0.618***	0.000	-0.367***	-0.976***	0.000
	(0.136)	(0.051)		(0.055)	(0.069)	
$\Delta CashHoldings_{i,t}$	-0.007***	-0.002*	0.001	-0.008***	-0.003***	0.0075
	(0.002)	(0.0011)		(0.0002)	(0.0008)	
$Q_{i,t}$	1.05e-7	2.21e-6	0.000	1.35e-8	3.06e-5	0.001
	(2.3e-7)	(3.6e-6)		(2.1e-8)	(6.2e-5)	
$Stkissues_{i,t}$	0.006**	0.006**	0.136	0.008**	0.007**	0.063
	(0.001)	(0.000)		(0.000)	(0.001)	
$CashFlow_{i,t}$	0.007***	0.003***	0.077	0.006***	0.002**	0.041
	(0.0005)	(0.0009)		(0.000)	(0.0008)	
$Size_{i,t}$	0.003***	0.002***	0.026			
	(0.0009)	(0.0008)				
m1	0	0.007		0.019	0	
m3	0.365	0.458		0.271	0.362	
J-test (p-value)	0.026	0.014		0.015	0.089	
Observations	2182	3763		2973	2972	

Note: All the columns are the estimation results by system GMM estimator. Industry and time dummies are included in the regressions. The instrument sets are all the independent variables lagged 3 times for the first difference equation and twice lagged for the level equation. Figures in parentheses are standard errors. J-test is Hansen test for over-identification, while m1 and m3 are the test of first and third serial correlation, respectively, in the first-differenced residuals. The p-value refers to a test of the null hypothesis that the values of the coefficients from different samples are equal.

Table 5.11 presents the regression results by splitting the sample in alternative criteria. Similar to the baseline model results shown in table 5.6, all the parameters are adequately identified except for Q. For the dividend payout criterion, firms with no dividend payout exhibit a higher sensitivity in changes in cash holding (-0.007) than firms paying dividends (-0.002). This implies the firms which are likely facing financial frictions are more likely to rely on the smoothing channel in the R&D investment. With respect to the firm size group, sample with smaller firms shows a higher coefficient value (-0.008) than the sample with larger firms (-0.003). The result is in accordance with the results shown in table 5.6, This result implies size is a crucial factor for firms of the R&D decision (Czarnitzki and Hottenrott, 2011; Guariglia and Liu, 2014), as well as the extent to which they would rely on the smoothing channel during the R&D project.

5.7 Conclusion

In this paper, we studied the relationship between R&D investment and changes in firm's cash holding level for Chinese listed firms in Shanghai and Shenzhen stock exchange. Theoretically, we use a reduced Euler equation to investigate how the changes in cash flow can smooth the R&D outlay in the presence of the shocks. Empirically, we employ a panel of over 6000 observations from 2007 to 2016 to find the linkage between the R&D expenditure and Δcashholdings.

The main findings are concluded as below. First, by the estimation of the baseline model, we find that the change of cash holdings, which is regarded as a "smoothing channel", is negatively related to the R&D investment, indicating that cash holding plays a smoothing role in the R&D investment in the presence of short-term cash flow fluctuation. Firms with R&D both use the external and internal finance to fund the R&D project, which is also in accordance with the findings in the literature. In terms of the size, larger firms are more prone to invest in the R&D. This is because larger firms are more likely to have more funds for the R&D activity and more easily access the bank loans than their smaller counterparts (Guariglia and Liu, 2014). For firms with different type of ownerships, SoE firms may not rely on the smoothing channel during the innovation project, which may be due to the soft budget constraint. However, even the SoE firms need to access internal funds to support innovation. In the augmented model with cash flow interaction, we find that higher level of cash flow will weaken the R&D investment smoothing mechanism. With respect to the firm's productivity, both high and low productive firms use the smoothing channel during the R&D investment. However, firms with high level of productivity are more sensitive to the changes in cash holding than that in lower productivity counterparts. This may be explained as the self-selection effect between the productivity and the R&D investment (Aw et al., 2008). In terms of the ownership structure, firms with lower level of the ownership concertation are more sensitive to Δcashholding than those with higher ownership concenttation. This implies that diffusely held firms can take advantage of using the smoothing channel in their R&D projects. Finally, the results from the robustness checks are generally consistent with the baseline results and hypotheses are all supported.

The limitations of this paper can be concluded as follows. Firstly, the sample we used in this paper is from A-shares listed firms in China, which are likely to have better financial conditions than firms listed in small and medium boards or the unlisted firms. Secondly, the size of sample is small (only 6,000 observations). Finally, the sample period is from 2007 onward, which is unlikely to gauge how the financial crisis can impact on firm's R&D investment and cash holding behavior.

Chapter 6 - Concluding remarks

The main objectives of this thesis were to investigate how the financial constraint impacts on ta firm's real decisions. To be more specific, we select the key parameters which support the China's economic growth: international trade, investment, as well as the innovation activities. Two firm-level Chinese databases have been employed in the thesis. One is from the NBS database, including a sizable number of unlisted manufacturing firms. The other one include firms listed in Shanghai and Shenzhen exchange, which is smaller than the NBS database. The majority of the findings are in accordance with the literature, some interesting findings have emerged from the study as well. This chapter will briefly discuss the contributions and the key findings.

6.1 Contributions

In chapter 3, we investigate the relationship between changing firm's working capital and its export status. The main contribution of this chapter is that, by using the source of the internal funds, firms with liquidity constraints can overcome the sunk cost during the export. In chapter 4, we use the stochastic frontier approach (SFA) to examine the investment-cash flow sensitivity, as well as the investment efficiency of each observation. The contributions can be concluded in two points. First, the SFA can estimate financial constraint for each individual firm and at each point in time. Secondly, the marginal impact of firm characteristics can be tested directly as well. In chapter 5, we investigate whether the cash flow can smooth the firm's R&D investment. The contributions are twofold. Firstly, this is the first study to point out that ownership can affect firm's liquidity management. Secondly, we examine the relationship among innovation, productivity and ownership concertation by using a dataset from the largest developing country.

6.2 Summary of key findings and policy implications

In Chapter 3, we find that working capital investment shows most significant contribution to new exporters. Between continuous and switch exporters, working capital investment making a higher contribution to the export decision is larger in continuous groups. The effect is poorly determined in exited exporters. Among different types of ownerships, the SOE are least working-capital investment sensitive. For other three ownerships, private firms show the largest working capital investment effect on export decision, while foreign firms show the smallest effect. This is because the foreign group is less financially constrained than the other two. In addition, only firms with a relative high level of working capital can use working capital investment to promote the export activities. Finally, the results from IV probit model prove that the relationship between working capital investment and export decision is one-sided. The policy implications can be concluded as follows. First, if firms are willing to export, they need to improve the ability of working capital management. This is crucial for the switchers. In addition, the working capital investment should be particularly important for the collective firms, which exhibit the lowest exporter ratio among all the ownership groups.

The main findings of chapter 4 are as follows. First, in the empirical estimations, the key coefficients imply that cash flows, assets and coverage ratio of firms alleviate financial constraints, while the leverage adversely affects the firms' financial constraint. Furthermore, in the post estimation section, we find the majority of firms show a large distance from optimal investment level, indicating that they are faced with severe financially constraint. Private firms are more financially constrained than their SOE counterparts but the foreign group is less financially constrained than the collective group. Firms in the regions with superior level of legal institution show higher efficiency. Lastly, industries in the tertiary sector show a relative higher efficiency than industries in the secondary sector.

In Chapter 5, the first key finding is that cash holding plays a smoothing role in the R&D investment in the presence of short-term cash flow fluctuation. Large firms are more likely to invest in the R&D. SoE firms may not rely on the smoothing channel during the innovation project, which may due to the soft budget constraint. However, even the SoE firms need to access internal funds to support the innovation. In addition, if firms have higher level of cash flow, the R&D investment smoothing mechanism will be weakened. Firms with high level of productivity are more sensitive to the changes in cash holding than that in lower productivity counterparts. Firms with lower level of the ownership concertation are more sensitive to Δcashholding than that in higher ownership concertation firms. This implies that diffusely held firms can take advantage of using the smoothing channel in the R&D project.

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