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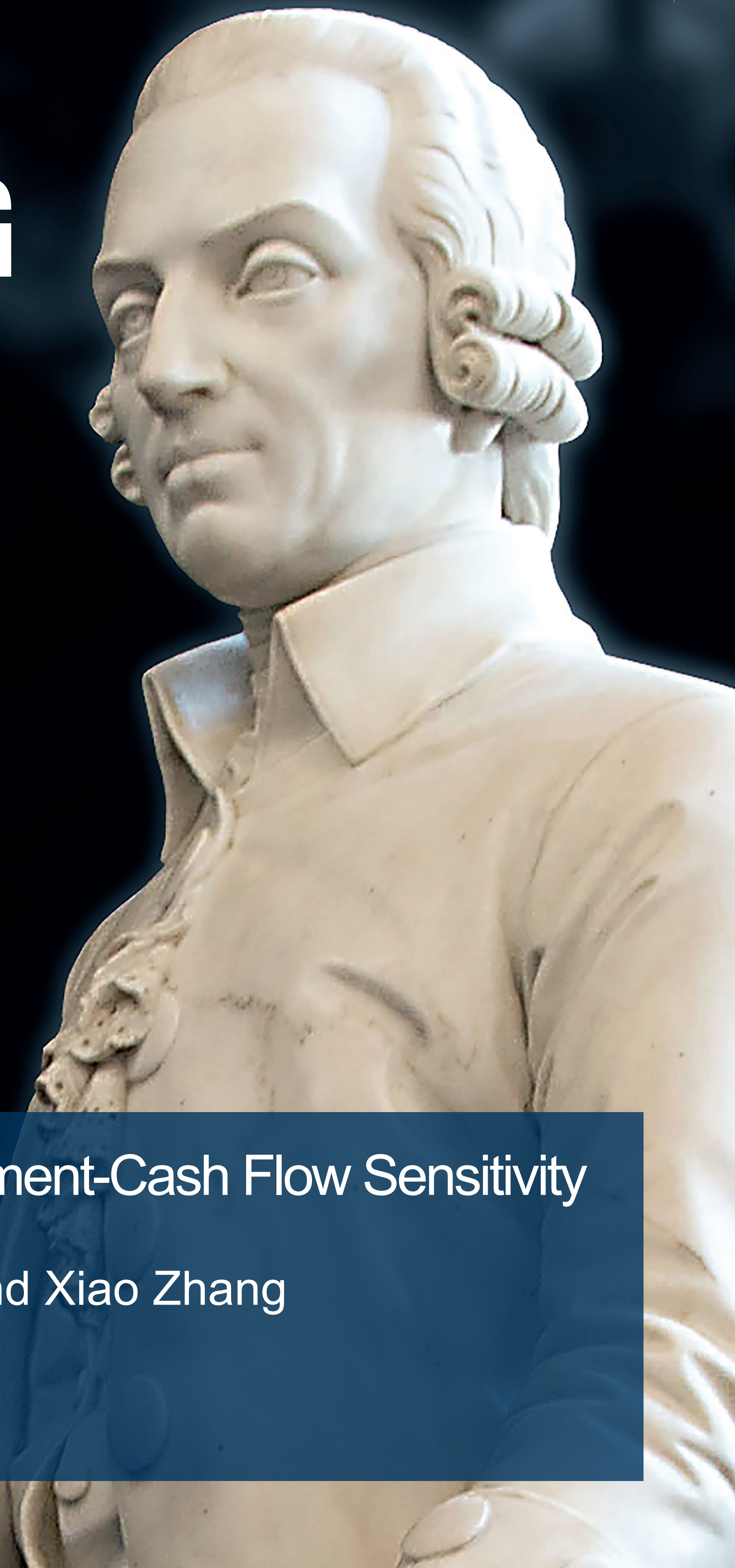

New Insight on Investment-Cash Flow Sensitivity

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Abstract

The investment-cash flow sensitivity (*ICFS*) of Chinese listed firms declined during the global financial crisis, which contradicts the conventional financial constraint interpretation of *ICFS*. We analyze this interesting phenomenon by examining how cash flow uncertainty affects the ways to finance investment in China. We find that *ICFS* reveals not only the information between investment and cash flow but also the relationship between internal funds and external financing. When internal funds and external financing are complements, cash flow uncertainty decreases *ICFS* much more than when internal funds and external financing are substitutes. Our results remain robust when we consider the problem of endogeneity and use alternative measures of key variables. Our story is also supported by the sample of US firms, indicating that our new interpretation of *ICFS* based on cash flow uncertainty and the relationship between internal funds and external financing can apply to the general literature of corporate finance.

JEL Classification: E22; G31; O16

Keywords: cash flow uncertainty, financial constraint, debt, cash flow, investment, China

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1 Introduction

The interaction between investment and financing decisions is of paramount importance in corporate finance and has been extensively explored and debated in the literature. One controversial question is whether investment-cash flow sensitivity (*ICFS* thereafter), defined as investment response to a change in cash flow, should be interpreted as financial constraints. In the seminal work of Fazzari et al. (1988), cash flow is the significant determinant of investment (even after controlling for Q) for financially constrained firms whose access to external financing is limited. Since then, *ICFS* has been widely used as an indicator of financial constraints despite criticisms (see Kaplan and Zingales, 1997; Erickson and Whited, 2000; Gomes, 2001). This view is further challenged by the recent literature which identifies the decline and disappearance of *ICFS* in the US during the 2007–09 credit crunch. If one believes that financial constraints have not completely disappeared, *ICFS* cannot be a good measure of financial constraints (Chen and Chen, 2012; Lewellen and Lewellen, 2016; Gutierrez and Philippon, 2017). However, the presence of positive *ICFS* is still commonly interpreted as financial constraints in developing countries like China where imperfect capital markets are prevalent (Guariglia et al., 2011; Cull et al., 2015; Ek and Wu, 2018).

Using the sample of Chinese listed firms, we offer a novel explanation of *ICFS* by taking into account the impact of cash flow uncertainty as well as the relationship between internal funds and external financing. We are motivated by a number of interesting stylized facts. First, using the method of Fama and MacBeth (1973), we estimate the conventional Q model of investment based on the year-by-year, cross-sectional regressions over the period of 1999–2017. As shown in Figure 1, *ICFS* gradually increased in the first 10 years and peaked in 2004–2006, but dropped sharply after 2008 when the global financial crisis (hereafter, GFC) started and remained pretty low. The average figure of *ICFS* is 0.25 in the pre-GFC and 0.16 in the post-GFC. This is counter-intuitive as the standard literature predicts that investment is more sensitive to cash flow during recessions when external financing is more costly and firms are more financially constrained (McLean and Zhao, 2014). This interesting finding suggests that, similar to the case of the US, *ICFS* cannot be a good proxy for financial constraints in China, especially after the GFC when the economic uncertainty is high. So, how do we understand *ICFS* and why does it decline in the post-GFC?

Second, the cross-sectional standard deviation of cash flow (CFSD) displays an opposing trend in Figure 1, which was low and stable before the GFC, but quickly climbed up after the GFC and gradually fell to the pre-GFC level after its peak in 2010. The average figure of CFSD is 0.11 in the pre-GFC and 0.24 in the post-GFC. This echoes the growing concerns about the risk and uncertainty embedded in the Chinese economy in general and in its financial system in particular (Song and Xiong, 2018). There exists a strong negative relationship between the time series trends of *ICFS* and CFSD (−0.58). Hence, can the costly cash flow uncertainty be a possible driver of *ICFS*, and if so, what are the possible channels?

[FIGURE 1 about here]

Lastly, the relationship between the aggregate values of investment and various financing sources (cash flow, debt and equity issuance) of listed firms is illustrated in Figures 2 – 4. We find that investment is highly and positively correlated with cash flow (0.70), indicating that firms direct much of cash flow toward incremental investment in a country whose economic success is driven by massive investment. The correlation between debt and investment is even higher (0.80), which can be explained by the dominance of a banking sector with large state-owned banks in China's financial system (Allen et al., 2017)[1]. By contrast, investment and equity issuance are negatively correlated (-0.46). Despite the recent development of Chinese stock market and rising proportion of equity issuance, listed firms heavily rely on debt financing, which accounts for more than 90 percent of the total external financing. Moreover, Figure 5 shows that debt and cash flow are strongly and positively correlated (0.79) among Chinese listed firms. Thus, given the important role of debt in the firm investment and the high correlation between debt and cash flow, can debt be a possible channel through which cash flow uncertainty impacts *ICFS*?

[FIGURES 2 – 5 about here]

Our contributions lie in the following four aspects. First, unlike the weak investment in the US and its 'investment less growth', China invests a lot and its growth success is mainly investment-driven (Song et al., 2011; Knight and Ding, 2012). According to the World Bank data, China's real gross fixed capital formation averaged a fairly steady 36 percent of real GDP over the period of 1978–2018, which is more than 1.6 times as large as that of the US (21%). Thus, our research on the intuition behind *ICFS* can provide insights on important questions such as why Chinese firms have strong incentives to spend capital on investment and how such high investment is financed.

Second, the existing literature on *ICFS* draws mainly from the pecking order theory which emphasizes the substitutability between internal funds and external financing; that is, more profitable firms (with abundant cash flow) require less costly external financing due to asymmetric information (Myers and Majluf, 1984; Fazzari et al., 1988). Inspired by the arguments of Almeida and Campello

[1] Corporate debt as a share of GDP has been persistently high in China and the trend has further increased to over 150% in 2014, whereas the corresponding figure for the US is 67% (BIS data).

(2010) on the complementary relationship between cash flow and debt as well as the supporting evidence from Figure 5, we, for the first time in the literature, develop and rigorously test four theoretical hypotheses about the impact of cash flow uncertainty on *ICFS*, including the pecking order theory, capital adjustment cost, liquidity channel and credit multiplier channel. Our empirical evidence is found to support these theoretical predictions.

Third, in order to shed light on causality, we take into account the unique Chinese institutional background and examine the heterogeneous responses of different ownership groups to the exogenous shocks which potentially affect the cash flow uncertainty of Chinese firms such as the GFC and post-GFC economic stimulus package. This novel empirical design not only alleviates the potential endogeneity problem, but also generates important policy implications.

Last, despite using China as a primary example, our research on the link between cash flow uncertainty and *ICFS* is applicable to the general corporate finance literature as the results based on the sample of US firms also support our story. This fills another gap in the literature left by Chen and Chen (2012) and Lewellen and Lewellen (2016); that is, by taking into account the impact of cash flow uncertainty and the relationship between internal funds and external financing, we can offer a new explanation for the decline and disappearance of *ICFS* in the US.

Using the sample of Chinese listed firms over the period of 1998–2017, we find that the direct impact of cash flow volatility, our main measure for cash flow uncertainty, on investment is negative but negligible, whereas the cash flow volatility affects firm's investment mainly through the indirect channel of *ICFS*. The negative impact of cash flow volatility on *ICFS* becomes larger as the complementary relationship between cash flow and debt becomes stronger. This is in line with our hypotheses based on various economic theories regarding the relationship between internal funds and external financing. The result remains robust when we opt for the downside cash flow volatility and stock return volatility, and when we control for the problem of measurement error in Q. We design a variant of Difference-in-Difference (DID) method to mitigate the problem of endogeneity, and our results confirm the exogenous impact of cash flow volatility on *ICFS*. Lastly, our main finding is also supported by the the sample of US firms for the same sample period, suggesting the validity of our theory and empirical findings in the general literature.

The structure of the paper is organized as follows. Section 2 reviews the relevant empirical and theoretical literature and discusses the background information of Chinese financial system. Section 3 develops our theoretical framework on the impact of cash flow uncertainty on *ICFS*, which is based on four different theoretical arguments on the relationship between internal and external financing. Section 4 discusses our empirical methodology including variable definition and model specification.

Section 5 reports the summary statistics and empirical results. Section 6 conducts an exogenous shock analysis in order to alleviate potential endogeneity and multicollinearity problems. Section 7 reports the results of further robustness checks with alternative measures of key variables. Section 8 tests our hypotheses using the US data. Section 9 concludes the paper.

2 Related Literature and Background

2.1 The literature on *ICFS*

A firm's financial status is irrelevant for real investment decisions in a world of perfect capital markets, as demonstrated by Modigliani and Miller (1958). However, Fazzari et al. (1988) claim that firms may face a wedge between the internal and external costs of funds in the presence of imperfect capital markets, and internal cash flow plays an important role in determining firms' investment when they are financially constrained. A positive *ICFS* (after controlling for Q) is interpreted as evidence for the existence of financial constraints. This is however challenged by a large number of literature. For instance, Kaplan and Zingales (1997) find that the degree of a firm's financing constraint does not vary monotonically with its *ICFS*. Erickson and Whited (2000) claim that investment is insensitive to cash flow when the measurement error in Q is controlled for using a GMM estimator based on higher order moment conditions. Gomes (2001) argues that the positive *ICFS* is due to a combination of measurement error in Q and identification problems. Abel (2018) develops a theoretical model and claims that *ICFS* is positive and larger for faster growing firms in the absence of financial constraints.

More recent debate focuses on the small and diminishing role of cash flow in determining firm's investment in the US. Brown and Petersen (2009) argue that the decline of *ICFS* is because firms have shifted their investment from physical investment to R&D, which is not typically included in the traditional measure of investment. Using time series data, Chen and Chen (2012) explore a number of possible reasons for the decline and disappearance of *ICFS* even during the credit crunch but find it still puzzling. Gutierrez and Philippon (2017) find that the US firms are reluctant to invest despite a high Q because of the rising intangibles, decreased competition, and policies encouraging payouts instead of investment. In contrast, Lewellen and Lewellen (2016) and Ağca and Mozumdar (2017) claim that cash flow remains the significant determinant of investment for US firms when a number of measurement errors and identification issues are addressed.

There is vast heterogeneity on *ICFS* across the world. Moshirian et al. (2017) argue that a declining share of tangible capital and falling investment translate into a decline in *ICFS* in most developed countries, whereas a high level of tangible capital stock and high rate of investment support a nondiminishing *ICFS* in developing countries. Larkin et al. (2018) also find that *ICFS* is positive and persistent in poor countries, but declines sharply in rich countries. They claim that financial development and economic growth explain the *ICFS* heterogeneity across countries and over time.

In the case of China, a common finding is that fixed investment is not sensitive to cash flow for state-owned enterprises (SOEs), whereas *ICFS* is positive and significant for non-state firms (Guariglia et al., 2011; Ding et al., 2013; Cull et al., 2015). The interpretation is that SOEs benefit from soft budget constraints or favorable treatment from banks, thus they are not financially constrained. On the other hand, private firms are generally discriminated against by the formal financial system and have to rely predominantly on internal funds for investment (Allen et al., 2005; Knight and Ding, 2012).

2.2 The theoretical literature on uncertainty and investment

According to the real options theory (Dixit and Pindyck, 1994), uncertainty may affect both the level and timing of investment, where they emphasize the role of irreversibility in shaping firms' investment decisions by applying the option pricing approach to investment theory. Investment is irreversible when it cannot be recovered after being installed. There is an option value to postpone an investment decision in order to wait for the arrival of new information about future market conditions. In an uncertain environment, irreversibility increases the value of waiting for the uncertainty to be at least partly dispelled, and naturally leads to depressing current investment and delaying investment projects. Thus, the rise in uncertainty boosts the threshold that triggers investment, thereby lowering the present investment level.

The negative correlation between investment and uncertainty predicted by the real options theory has been widely debated. Caballero (1991) finds that only if irreversibility is assumed in combination with decreasing returns to scale or imperfect competition, uncertainty will have a negative effect on investment. In the extended real option framework, both Abel et al. (1996) and Abel and Eberly (1999) discover an ambiguous effect of uncertainty on investment.

A different channel through which uncertainty affects investment relates to risk preference. Nickell (1978) shows that risk attitude may have either positive or negative effects on investment decisions under uncertainty. It is generally agreed that risk aversion depresses investment under uncertainty (Aizenman and Marion, 1999; Nakamura, 1999). By contrast, when taking into account the nature of marginal product of capital, a number of researchers (Hartman, 1972; Abel, 1983; Abel and Eberly, 1994) prove that the investment-uncertainty relation can be positive under certain assumptions. For instance, a rise in uncertainty can raise the expected present value of the marginal profit flow when the marginal profit function is a convex function of uncertainty and therefore lowers the investment threshold, which encourages investment.

Capital market imperfections or financial constraints can lead to a negative relationship between uncertainty and investment. According to Greenwald and Stiglitz (1990), there exist various conflicts of interest and information asymmetries between creditors and shareholders. Such agency costs result in higher cost of capital and in this way, an increase in uncertainty over firms' profitability makes firms reluctant to invest. In brief, there is no consensus on the theoretical grounds for the relationship between uncertainty and investment.

2.3 The literature on cash flow volatility

The uncertainty of cash flow and the risk of adverse cash flow shocks are central concerns in corporate finance and are taken seriously by both managers and shareholders (Disatnik et al., 2014). Cash flow volatility is costly as low cash flows may throw budgets into disarray, distract managers from productive work, defer capital expenditure or delay debt repayment (Minton and Schrand, 1999). The cash flow volatility has been studied across several areas, including firm's investment, capital structure, cash holdings, and dividend payouts.

Minton and Schrand (1999) discover both the direct and indirect negative effects of cash flow volatility on investment. First, higher cash flow volatility increases the frequency of cash flow shortfalls, which directly reduces investment. Second, increased cash flow volatility raises the firm's external financing costs, which indirectly shrinks investment. The rationale is that firms with uncertain cash flow have more difficulty accessing external financing and face higher cost of capital given the higher risks to capital providers. This leaves firms more financially constrained as they must forgo investment due to insufficient capital.

There is no consensus on the impact of cash flow volatility on capital structure. On the one hand, Keefe and Yaghoubi (2016) adopt the Black and Scholes (1973) model to illustrate the positive relationship between cash flow volatility and the cost of debt. They find that the cash flow volatility has a negative effect on a firm's capital structure by reducing the long-term debt ratio. On the other hand, Harris and Roark (2019) find that firms with higher cash flow volatility have higher debt levels for firms, and this positive link holds only for those with the greatest shortfall in operating cash flow, i.e. firms at greater risk of a cash shortfall will increase their use of debt.

The literature on corporate cash holdings identifies a positive link between cash flow volatility and cash. For instance, Opler et al. (1999) claim that the optimal amount of cash increases in the volatility of cash flows from existing assets, and firms operating in more volatile industries hold significantly more cash as a fraction of their assets. Han and Qiu (2007) argue that cash holdings of financial constrained firms are sensitive to the cash flow volatility, and when future cash flow risk cannot be fully diversified, constrained firms increase their cash holdings in response to rise in the cash flow volatility. Bates et al. (2009) find that an increase in the cash flow volatility may lead to cash shortfalls for firms, and firm's cash holdings increase as a response to increased cash flow risk.

There is also a literature addressing the importance of cash flow uncertainty in payout policy. Using cross-country data of 7 advanced economies, Chay and Suh (2009) find that firms facing high cash flow uncertainty are more reliant on internal funds and pay low dividends fearing future cash shortfalls. In contrast, Deng et al. (2013) find that when facing uncertain cash flow, Chinese firms neither cut dividends nor investment, but use external financing as an instrument to resolve cash flow uncertainty. They argue that China's special institutional settings provide firms with strong incentives for both dividend payout and investment.

2.4 The literature on the relationship between internal and external funds

The traditional corporate finance literature regards cash flow and debt as substitutes in financing firm's investment. According to Modigliani and Miller (1958), external funds provide a perfect substitute for internal capital with a perfect capital market, making a firm's financial structure irrelevant to investment. In contrast, Fazzari et al. (1988) show that external financing is more costly than internal funds in an imperfect capital market where asymmetric information, transaction costs and agency problems are prevalent, so the internal and external sources of funds are not perfect substitutes. The imperfect substitutability between internal funds and external financing is well accepted in the literature (Froot et al., 1993; Kaplan and Zingales, 1997; Rauh, 2006).

There is a rising literature focusing on the complementarity between cash flow and debt. For instance, Holmstrom and Tirole (1997) construct a model where a firm's net worth determines its debt capacity, and find that firms with substantial net worth can obtain cheaper debt financing. Assuming that firm's investment is endogenous to external financing decisions, Almeida and Campello (2010) claim that internal funds and external financing can become complements rather than substitutes when external financing costs are high. The positive relationship between cash flow and debt is stronger for financially constrained firms with more tangible assets or with greater propensity to use cash flow surplus to accumulate liquidity. Lian and Ma (2021) find that in the US, about 80% of debt is based on cash flow from firms' operations ('cash-flow based lending'), whereas merely 20% of debt is collateralized by physical assets ('asset-based lending'). The prevalence of 'cash-flow based lending' indicates that cash flow in the form of operating earnings can relax firms' borrowing constraints, and therefore increasing investment.

2.5 Background of China's inefficient financial system

China is commonly regarded as a counterexample to the findings in the finance-growth literature as the development of the financial sector is lagging behind that of the overall economy (Allen et al., 2005). The financial system is inefficient and 'repressed' where government intervention is prevalent in both the banking system and stock market in order to keep unprofitable SOEs afloat during the reform process.

First, the banking system is dominated by five large state-owned banks, which mainly serve the financing needs of large SOEs and government projects. Despite the gradual reform of the banking sector, soft budget constraint is present among SOEs which has adversely affected the performance of both SOEs and private firms (Chow et al., 2010). For instance, it is only in SOEs that bank loans constitute a major share of investment financing; these loans are made at rates well below what would have been the competitive rate of interest for borrowers, and are made without close monitoring (Ding et al., 2018). By contrast, the private sector, the driving force of the economy, is generally discriminated by the formal banking system and has to pay high interest rates on rationed loans or rely on internal funds or alternative sources of financing for investment (Guariglia et al., 2011; Ding et al., 2013; Cull et al., 2015). Thanks to the ownership reform such as 'grasp the large, let go of the small'[2] as well as the new rules and regulations that made commercial banks more independent, the problem of soft budget constraint has been greatly mitigated since the late 1990s. According to Lardy (2014), although SOEs still receive a share in bank loans that is disproportionate to their diminishing share in the economy, the access of private firms to bank credit has improved dramatically in recent years.

Second, China's stock market has developed quickly since 1990s, and become one of the largest ones in the world in terms of market capitalization. However, it is highly inefficient. For instance, large amount of shares in listed companies are owned by the government and government entities, and only until recently the majority of listed firms' shares are tradable; most individual and institutional stockholders are short-term speculative investors. Hence, the prices and market valuations may not reflect firms' long-run prospects and fundamentals (Morck et al., 2000). It is not surprising to find that commercial banks, rather than stock market, are the main supplier of new capital for listed firms in China (Jiang et al., 2020).

[2]Small SOEs were closed or privatized, whereas large SOEs were merged into large industrial conglomerates and control over them was consolidated by central and local governments (Hsieh et al., 2015).

3 Hypothesis Development

3.1 Definitions

We first define *ICFS* in a simple framework. For a positive cash flow shock, the firm will direct some of the increased internal funds (A) toward incremental investment or use those funds to attract/cut back on external financing (B). Thus, we define *ICFS* as

$$ICFS \equiv \underbrace{I_A}_{\text{Interanl funds channel}} + \underbrace{I_B B_A}_{\text{External financing channel}} \tag{1}$$

where $I_A = \partial I/\partial A$, $I_B = \partial I/\partial B$, and $B_A = \partial B/\partial A$.[3] From (1), the sensitivity of *ICFS* to cash flow uncertainty is also determined through the two channels:

$$ICFS_\sigma = \underbrace{I_{A\sigma}}_{\text{Internal funds channel}} + \underbrace{I_B B_{A\sigma}}_{\text{External financing channel}} \tag{2}$$

where $ICFS_\sigma = \partial ICFS/\partial\sigma$, $I_{A\sigma} = \partial^2 I/\partial A\partial\sigma$, and $B_{A\sigma} = d^2B/dAd\sigma$.[4]

Following the basic arguments of Almeida and Campello (2010) and Lian and Ma (2021), we develop our own hypotheses about the impact of cash flow uncertainty on *ICFS*. Since both internal funds and external financing are the main channels to determine *ICFS*, our focus is on the relationship between internal funds and external financing and its role in determining the impact of cash flow uncertainty on *ICFS*. A relation between internal funds and external financing can be either substitutable (negative B_A) or complementary (positive B_A), and these relationships are closely associated with various theoretical channels discussed as follows.

3.2 Theoretical Arguments

3.2.1 Pecking order theory

In the standard pecking order theory that assumes fixed investment, firms prefer to finance investments with internal funds due to external financing costs increased by asymmetric information (Myers, 1984;

[3] Given desired investment based on the expected profitability, we assume that actual investment is determined by considering internal funds (cash flow) (A), external financing (debt/equity) (B) and cash flow uncertainty (σ). Thus, the total derivative of investment is given by $dI = (\partial I/\partial A)\, dA + (\partial I/\partial B)\, dB + (\partial I/\partial\sigma)\, d\sigma$. Then the total derivative of investment with respect to internal funds is given by $dI/dA = I_A + I_B B_A + I_\sigma \sigma_A$. We assume that cash flow uncertainty is not systematically related to the cash flow change. That is, increased or decreased cash flows does not increase cash flow uncertainty. So, σ_A is assumed to be zero. We define *ICFS* as $I_A + I_B B_A$ in our framework.

[4] Both investment and external financing are endogenous and they decrease simultaneously with the raise of cash flow uncertainty. Hence, without loss of information, it would be reasonable to assume that cash flow uncertainty does not affect the use of borrowed debt for investment. i.e. $I_{B\sigma} = \partial I/\partial B\partial\sigma = 0$.

Myers and Majluf, 1984). This preference generates a substitutable relationship between internal funds and external financing. However, their investment decisions are made before the realization of cash flow shock in the fixed investment model (Tirole, 2010). Following a positive cash flow shock, the firm increases the use of internal funds, reduces the use of external financing, but keeps the same level of investment. Thus, *ICFS* is zero. If cash flow uncertainty increases, both the frequency of cash flow shortfall and the cost of external financing increase. It makes the substitutable relationship stronger but does not influence *ICFS* due to the firm's predetermined investment decision. To sum up,

$$I_A = 0,\ I_B = 0,\ B_A < 0 \Rightarrow ICFS = 0 \tag{3}$$

$$I_{A\sigma} = 0,\ B_{A\sigma} < 0 \Rightarrow ICFS_\sigma = 0 \tag{4}$$

3.2.2 Capital adjustment cost

However, the pecking order theory does not clearly explain the strong substitutable relationship among financially unconstrained firms, which are characterized by low asymmetric information and predetermined investment. According to Strebulaev (2007), the presence of (small) capital adjustment costs can generate a negative relationship between profitability and issuance activity, i.e. profitable firms may choose to finance investment with internal funds to save on flotation costs. Hence, the relation between internal funds and external financing is either undetermined or (more likely) negative for the financially unconstrained firms. However, cash flow does not affect *ICFS* since the firm's investment is predetermined. For the same reason, cash flow uncertainty does not affect *ICFS*.

Hypothesis 1

Since the strong substitutable relationship between internal funds and external financing is mostly explained by the pecking order theory or adjustment cost, we set the first hypothesis as follows:

H1: *If there is a strong substitutable relationship between internal funds and external financing,* $ICFS = 0$ *and* $ICFS_\sigma = 0$.

If the firm is financially unconstrained and its investment decision is exogenous, observed investment is equal to the desired investment regardless of capital market frictions (e.g Shyam-Sunder and Myers, 1999). However, if the firm is financially constrained and its investment decision is endogenous, observed investment is lower than the desired level. Endogenous investment decision also influences the substitutable relationship between internal funds and external financing. As a result, *ICFS* and $ICFS_\sigma$ will change. We will develop these arguments in detail with the liquidity channel and credit multiplier channel.

3.2.3 Liquidity channel

The liquidity channel suggests that investment is variable. Therefore, the firm will make decisions on investment and cash holdings after the realization of cash flow shock. A firm with abundant internal funds will find it advantageous to direct some of those funds toward incremental investment. According to the liquidity arguments (Almeida and Campello, 2010), when the firm's external financing costs are high, the firm should consider not only the funds it needs for current investment but also for the future one. The most effective way for the firm to ensure spending on the future investment is to secure liquid assets for smoothing investment process. To this end the firm with the expensive external financing cost will use the rest of those funds to raise liquid assets rather than to reduce external financing (Fazzari and Petersen, 1993; Almeida et al., 2004). Therefore, this liquidity arguments can explain why financially constrained firms should display a lower propensity to use cash flows for the reduction of external financing, i.e. we will find weaker substitutable relationship from those firms.

First, a positive cash flow shock increases current investment and cash holdings reserved for future opportunities. However, financially constrained firms are reluctant to use debt to finance investment in respect that debt financing will exhaust their limited borrowing capacity and not be optimal for their dividend payouts (Almeida et al., 2004). Thus,

$$I_A > 0, I_B > 0, B_A < 0 \Rightarrow ICFS > 0.\text{[5]} \tag{5}$$

Second, if cash flow uncertainty increases, both the frequency of cash flow shortfalls and external financing costs increase. As a result, the firm will direct more internal funds toward liquid assets and use less internal funds to cut back on external financing. If the firm is financially more constrained, the firm will reduce even internal funds for incremental investment to raise more liquid assets. Therefore, cash flow uncertainty will negatively affect *ICFS* through the internal funds channel.

$$I_{A\sigma} < 0,\ B_{A\sigma} > 0 \Rightarrow ICFS_\sigma < 0.\text{[6]} \tag{6}$$

[5] According to the liquidity arguments, I_B and B_A have relatively very small sensitivity compared to I_A. Therefore, it would be reasonable to assume that the internal funds channel dominates the external financing channel, i.e. $|I_A| > |I_B B_A|$.

[6] As discussed in (5), the external financing channel has relatively very small sensitivity compared to $I_{A\sigma}$. Therefore, it would be reasonable to assume that the internal funds channel dominates the external financing channel, i.e. $|I_{A\sigma}| > |I_B B_{A\sigma}|$.

Hypothesis 2

The weak substitutable relationship or irrelevance is found in the liquidity arguments. Therefore, we set the second hypothesis as follows:

H2: *If there is a weak substitutable relationship between internal funds and external financing,* $ICFS > 0$ *but* $ICFS_\sigma < 0$.

3.2.4 Credit multiplier channel

The firm directs rising internal funds toward incremental investment, which increases its holdings of tangible assets. These create new collateral, which the firm can use to attract more external financing. This mechanism is "credit multiplier" introduced by Kiyotaki and Moore (1997), suggesting that financially more constrained firms face a stronger complementary relationship between internal funds and external financing. Therefore, investment will positively respond to a cash flow shock through both the internal funds and external financing channel. Since the complementary relationship contributes to incremental investment through external financing channel, it is likely to have a bigger positive *ICFS* than that of the substitutable relationship. To sum up,

$$I_A > 0,\ I_B > 0,\ B_A > 0 \Rightarrow ICFS > 0. \tag{7}$$

If cash flow uncertainty increases, external financing is more costly. Thus the firm has to reduce external financing given the collateral. To leave investment constant, the firm needs to direct more internal funds toward incremental investment because it needs to create more new collateral. However, since the large cash flow uncertainty increases the frequency of cash flow shortfall, it is difficult to increase investment using internal funds in practice. Therefore, cash flow uncertainty negatively affects *ICFS* through the external financing channel. If the firm's financial constraint is very tight and cash flow uncertainty very high, the firm could cut back on internal funds for incremental investment. Thus the negative impact of cash flow uncertainty on *ICFS* becomes stronger as the firm is financially more constrained. To sum up,

$$I_{A\sigma} \le 0,\ B_{A\sigma} < 0 \Rightarrow ICFS_\sigma < 0. \tag{8}$$

Hypothesis 3

The complementary relationship is described by the credit multiplier arguments. Therefore, we set the third hypothesis as follows:

H3: *If there is a complementary relationship between internal funds and external financing,*

$$ICFS > 0 \text{ but } ICFS_\sigma < 0.$$

ICFS is more positive and $ICFS_\sigma$ is more negative than the case of a substitutable relationship.

4 Methodology

Our goal is to test our theoretical hypotheses and provide evidence on $ICFS$ and $ICFS_\sigma$ for firms with a substitutable or complementary relationship between internal funds and external financing. To this end, we need a couple of empirical works. First, we need to develop an empirical model which links the firm's investment to cash flow and cash flow uncertainty. Second, the firm's cash flow uncertainty is not directly observable so we need to approximate it using a sample. Third, we also cannot directly observe the relationship between internal funds and external financing, which needs to be proxied using a sample. We will discuss these issues in detail.

4.1 Key variable construction

4.1.1 Cash flow uncertainty

Cash flow volatility Our main measure of cash flow uncertainty is cash flow volatility ($CFVOL$). We estimate the standard deviation of quarterly cash flow using sample over the previous T-year period. There is a trade-off between the length of time-period and the number of available year observation. The longer time-period can reduces the small sample bias of standard deviation estimates but loses more year observations. Thus we consider the various lengths of time-period; 6, 5, 4 and 3 years. For example, let's consider $T = 6$ used by Minton and Schrand (1999). For the sample year 2004, the standard deviation is calculated using 24 quarters of data from the first fiscal quarter of 1998 to the fourth fiscal quarter of 2003. A firm is included in the sample for a given year if it has non-missing observation over the six-year period. The standard deviation is then scaled by the absolute value of cash flow in 2004.

Downside risk Given firms' heterogeneous response to negative versus positive cash flow shocks, we adopt downside cash flow volatility, which directly links to cash flow shortfall, as an alternative proxy for cash flow uncertainty. First, we compute the mean of cash flow over the last T-year period. Then we define a deviation from the mean as a cash flow shock. We then compute the downside cash flow volatility ($DCFVOL$) using negative cash flow shocks:

$$DCFVOL = \frac{1}{nT}\sum_{t=1}^{nT}\epsilon_{i,t}^2 I\left\{\epsilon_{i,t} < 0\right\}, \tag{9}$$

where $\epsilon = CF - E[CF]$ is the cash flow shock and n is the number of observations within a year, e.g., if sample frequency is quarterly, then $n = 4$.

Stock return volatility In addition to the accounting-based measures, we adopt the stock return based measures of cash flow uncertainty as an alternative proxy. We measure the stock return volatility using the firm-specific constant-mean-return model which is the same model used for our accounting-based measure, i.e. the cash flow volatility. The difference is that we use monthly stock returns rather than the quarterly ones like cash flow. The monthly frequency could guarantee larger sample size and better statistical inferences than the quarterly one. We compute the standard deviation of the firm's stock return over the last T-year period, i.e. stock return volatility ($TOTVOL$). We can decompose $TOTVOL$ into the systematic part ($SYSVOL$) and the firm-specific part ($FIRMVOL$) based on the asset-pricing literature. It has the advantage of being able to analyze the uncertainty channel of the investment more specifically than the cash flow volatility. For the decomposition, a single index model, that uses market excess return as an explanatory variable, or a multi-factor model, that uses various common factors, is mostly used in the empirical studies. We use Fama and French (1993)'s three-factor model (hereafter FF3) to decompose $TOTVOL$ into $SYSVOL$ and $FIRMVOL$.[7] For each firm we estimate $SYSVOL$ using factors and estimated factor loadings, and $FIRMVOL$ using the regression residuals of the FF3 model given the estimation windows.

4.1.2 Relationship between internal funds and external financing

We estimate a correlation coefficient between internal funds and external financing using full year observation for each firm. Then we split all firms into four groups: "strong complementarity" (SC) if the correlation coefficient > 0.6, "weak complementarity" (WC) if > 0.2 and ≤ 0.6, "weak substitutability" (WS) if < -0.2 and $-0.6 \geq$ and "strong substitutability" (SS) if ≤ -0.6, respectively.[8] We truncate a range between -0.2 and 0.2 and classify the range as the "neutral" group to alleviate the potential estimation error of the correlation coefficient.

Note that it is a more general assumption that the relationship between internal funds and external financing can change over time. However, it is also a realistic assumption that there will be no

[7] We also use the single index model and find quantitatively consistent results.

[8] Although the threshold for the correlation coefficients used to divide groups is arbitrary, this method is prevalent in the empirical asset pricing study (e.g. 5x5 portfolios). It is also consistent with our theoretical hypothesis.

drastic change like a sign change of the correlation coefficient between internal funds and external financing. In addition, it is practically impossible to collect enough annual-frequency samples to estimate the time-varying correlation coefficient for each firm. For these reasons, we estimate the average relationship between internal funds and external financing for each firm using full-year observations. Although it is not entirely time-variant, Section 6 allows the time-varying nature by separately estimating correlation coefficients for the pre- and post-GFC.

4.1.3 Financial constraints

There are numerous studies on how to measure a firm's financial constraint. Following the literature (Fama and French, 2002; Almeida and Campello, 2010), we use firm size as the main measure for financial constraints, assuming that small firms are typically young, less established and more subject to credit imperfections[9]. We also use an index-based measure, the WW index (Whited and Wu, 2006) to proxy for financial constraints,

$$WW = -0.091CF - 0.062DIVPOS + 0.021LEV - 0.044SIZE + 0.102ISG - 0.035SG,$$

where LEV is the ratio of debt to total asset, $CASH$ is the ratio of liquid assets to total assets, $DIVPOS$ is a dummy indicating positive dividends, $SIZE$ is the natural log of total assets, ISG is the firm's 3-digit industry sales growth, and SG is sales growth. This measure has been widely used in both the general and China-specific literature (see Hennessy et al., 2007; Guariglia and Yang, 2016). A higher value of the WW index is associated with firms more likely to be financially constrained and facing higher costs of external financing.

4.2 Test of hypothesis

Our empirical model augments the classical reduced-form investment regression model by including the cash flow volatility. The baseline empirical model is written as

$$INV = \beta_0 + \beta_1 Q + \beta_2 CF + \beta_3 CFVOL + \beta_4 CFVOL{\cdot}CF + Firm + Industry + Year + \epsilon, \tag{10}$$

where investment (INV) is defined as capital expenditure (the cash paid to acquire and construct fixed assets, intangible assets and other long-term assets, scaled by the lagged assets). Cash flow (CF) is measured by cash received from sales of goods or rendering of services, scaled by the lagged assets.

[9] Almeida and Campello (2010) use four measures, i.e. payout, size, bond rating and commercial paper rating. But payout is vary rare among Chinese firms, and bond rating and commercial paper rating are not available in our dataset.

Cash flow volatility ($CFVOL$) is the proxy for cash flow uncertainty as introduced. The interaction term between $CFVOL$ and CF is the key variable of interests testing for the effect of cash flow uncertainty on $ICFS$. We use lagged Tobin's Q (market value of equity plus book value of debt normalized by book value of assets) as a proxy for investment opportunity. We control firm, industry[10] and year fixed effects, and ϵ denotes the remainder idiosyncratic stochastic disturbance.

We also extend this baseline model by controlling further firm heterogeneity:

$$INV = \beta_0 + \beta_1 Q + \beta_2 CF + \beta_3 CFVOL + \beta_4 CFVOL{\cdot}CF + \gamma' X + Firm + Industry + Year + \epsilon, \tag{11}$$

where X is a vector of control variables, including stock returns, cash holdings, book leverage, fixed assets, margin, and firm size as in Lian and Ma (2021).

Stock return in the past 12 months (RET in year $t-1$) is argued to be a useful empirical proxy for Q (see Barro, 1990; Lamont, 2000). Firm cash holding at the end of $t-1$ ($CASH$) is included and we expect a positive relationship between cash holdings and investment because firms hold cash to avoid underinvestment (Denis and Sibilkov, 2010).

Book leverage (LEV), a measure of the amount of external financing used by firms, has ambiguous effect on investment. On the one hand, high leverage may be interpreted as indicating high debt capacity or low external financial constraints (Fazzari et al., 1988). On the other hand, high leverage may indicate a firm's poor financial performance and highly leveraged firms are less likely to get external financing (Lang et al., 1995; Kaplan and Zingales, 1997). Firth et al. (2008) find a negative relationship between leverage and firm investment in China.

Fixed asset (FA) is included to proxy for tangibility, and greater tangibility is often associated with less financial constraint and more investment (Almeida and Campello, 2007). Profit margin or profitability ($MARGIN$) is measured as the difference between sales and cost of sales scaled by sales, which can be used as an alternative proxy for Q.

Lastly, firm size ($SIZE$) is included to control for firm heterogeneity, and its effect on investment can be inconclusive. On the one hand, firm size is regarded as an inverse proxy for the extent of informational asymmetries between a firm's insiders and external financing providers, and smaller firms may face higher hurdles when raising external capital than large firms (Myers and Majluf, 1984). On the other hand, large firms are mature firms with less growth momentum than small firms, and they are more likely to suffer decreasing return to scale and thus invest less. Lin et al. (2011) find a

[10] If a firm's industry classification is unchanging throughout the sample period, the fixed-effects estimator removes industry dummies. However, the industrial classification of Chinese firms often changed within the sample period. Thus, we control the industry effects by using industry dummies. For US firms, it is not necessary to use industry dummies.

negative effect of firm size on firm investment in China. Note that cash holdings, book leverage and fixed assets are scaled by the current total assets.

Our focus on *ICFS* and $ICFS_\sigma$ is captured by β_2 and β_4, respectively. To test Hypothesis 1, we estimate the empirical model for the SS group and perform the two-tailed t-test for $H_0 : \beta_2 = 0$ and $H_0 : \beta_4 = 0$, respectively. If we do not reject the two null hypotheses, it statistically supports Hypothesis 1. Unlike the test of Hypothesis 1, we need a one-tailed t-test for Hypothesis 2 and 3, because we are interested in testing $ICFS > 0$ and $ICFS_\sigma < 0$. To this end, we estimate the empirical model for WS, WC, and SC respectively, and perform the one-tailed t-test of $H_0 : \beta_2 \leq 0$ and $H_0 : \beta_4 \geq 0$ for each group. If we reject the two null hypotheses for WS, it statistically supports Hypothesis 2. Analogously, if we reject the two null hypotheses for WC and SC, it statistically supports Hypothesis 3.

5 Empirical Analysis

5.1 Sample and summary statistics

We use firm-level data of Chinese listed firms provided by the China Stock Market & Account Research (CSMAR) database. Our sample covers the period of 1998 – 2017. Following the standard data cleaning approach used in literature, we first exclude all the firms in the financing sector identified by CSMAR's industry code '001' and China Securities Regulatory Commission (CSRC) industry code 'J'. We drop observations when the investment has a missing value and winsorize all variables at the 1st and 99th percentiles to control outliers.

Our final panel data consists of 3,052 listed firms over the period 1999 – 2017[11]. There are 30,677 firm-year observations. On average the number of firm-year observations for each firm is 10. The number of observations varies from a minimum of 799 in 1999 to a maximum of 2,713 in 2017. In addition to key variables, we construct a number of variables commonly used in the investment literature (see McLean, 2011). The definitions of variables are presented in Appendix A. Following Lian and Ma (2021), we scale all flow variables by lagged total assets and all stock variables by current total assets.

We compare the summary statistics of variables used for our empirical analysis for China with US in Table 1. First, for China, the mean of investment, 0.067, is higher than that of operating cash flow, 0.051, indicating that the internal funds cannot fulfill firm's investment need and the gap has to be filled by external financing. The case is opposite for the US, where the mean of investment (0.06) is lower than that of operating cash flow (0.076), confirming that the US firms are less willing to use cash flow to finance its investment. By contrast, the R&D investment of US firms (0.063) is much higher

[11] The year 1998 is missing due to the use of lagged variables.

than that of Chinese firms (0.025), and US firms have much larger intangible assets (0.169) than their counterparts in China (0.045). These findings are in line with the literature that R&D becomes a more important form of investment in the US, whereas the role of tangible capital and fixed investment has declined (see Brown and Petersen, 2009; Moshirian et al., 2017). Thus, the important role of fixed investment in the Chinese economy makes it an ideal laboratory for our experiment.

[Table 1 about here.]

Second, the cash flow volatility exhibits little change for China and the US with respect to changes in the estimation period from 3- to 6-year, indicating that our testing results will be robust to the choice of different estimation period of cash flow volatility. The mean value for China is about three times as much as that for the US, justifying our choice of using China as the main example for a study on the impact of cash flow uncertainty.

Third, taking a closer look at the financial resources of investment, we find that debt financing is more important for Chinese firm (26%) than for US firms (12%). In China, the mean of debt (26%) is much higher than that of equity issuance (3%), implying that firms prefer debt to equity. The median of equity issuance is zero, meaning that at least half of the samples have never issued shares. This is consistent with the fact that China's financial system is dominated by a banking sector with large state-owned banks, and despite the rapid development of Chinese stock markets, the investment-driven economic growth is mainly financed by debt (Allen et al., 2017). By contrast, the median of equity issuance of US firms is 0.005, while the median of debt is zero, suggesting that US firms prefer equity issuance to debt.

Figure 6 presents the proportion of firms using debt or equity issuance, and the average ratio of debt to total asset (hereafter, debt ratio) and equity issuance to total asset (hereafter, equity ratio) during the period of 1999-2017 in China. We find that Chinese listed firms rely heavily on debt financing, i.e. about 90 percent of firms used debt in the pre-GFC and the figure slightly decreased to 80 percent in the post-GFC. In the case of equity issuance, only about 40 percent of firms issued equity in the pre-GFC and the figure slightly increased to 50 percent in the post-GFC. Moreover, the average debt ratio is 26% over the sample period, whereas the average equity ratio is merely 3%. In the post-GFC, the average debt ratio decreased slightly to 24%, but the average equity ratio remained low at 4% despite a small rising trend. In brief, the important role of debt financing indicates that the variation of external financing in our empirical analysis is mainly determined by debt. We will thus base our main analysis on debt financing.

[FIGURE 6 about here.]

Lastly, we examine the patterns of key variables across four groups sorted by the correlation between cash flow and debt defined in Section 4.1, i.e. strong substitutability (SS), weak substitutability (WS), weak complementarity (WC) and strong complementarity (SC). In Figure 7, as the substitutable relationship becomes stronger as in the SS group, firms are large and mature with low levels of Tobin's Q and cash flow but high level of debt. These firms are the least financially constrained (indicated by both large size and low WW), whose investment decisions can be made less dependent on external financing, i.e. their investment decisions are more exogenous. Thus, firm's investment in the SS group is entirely dependent on Tobin's Q, but rarely relying on cash flow. On the contrary, as the complementary relationship becomes stronger as in the SC group, firms are small and young with high levels of Tobin's Q and cash flow. However, these firms have much limited access to external capital markets such as debt. This is consistent with the concept of 'cash flow-based lending' as introduced in Lian and Ma (2021) that a borrowing constraint restricts debt as a function of cash flows measured using operating earnings. Therefore, their investment decisions are dependent on available internal funds (cash flow), where financial constraints and endogenous investment decisions are related to determining $ICFS$ and $ICFS_{\sigma}$.

[FIGURE 7 about here.]

5.2 Identifications

Before testing our hypotheses using the baseline model in Section 4.2, we need to empirically resolve an identification issue regarding whether it is a necessary condition to identify the relationship between internal funds and external financing by the theoretical channels discussed in Section 3.2.

5.2.1 Pecking order theory

The pecking order theory is the arguments about financially constrained firms. We should observe that the firms with larger information asymmetry have a stronger substitutable relationship. Therefore, in the following regression model,

$$DEBT = \beta_0 + \beta_1 CF + \beta_2 INFASY + \beta_3 INFASY \cdot CF + Firm + Industry + Year + \epsilon, \qquad (12)$$

β_3 should be negative.

The variable $INFASY$ denotes the variable of information asymmetry in the regression model. We use accruals quality as a proxy for information asymmetry. We follow the spirit of Lee and Masulis (2009) and extend their FDD model by controlling both industry and year effects in the single panel regression model with the entire sample of firm years:

$$CA = \gamma_0 + \gamma_1 LCF + \gamma_2 CF + \gamma_3 FCF + \gamma_4 \Delta SALES + \gamma_5 FA + Firm + Industry + Year + \epsilon, \tag{13}$$

where CA is total current accruals which is computed by Δcurrent assets − Δcurrent liabilities − Δcash + Δdebt in current liabilities, where Δ is a change from year $t-1$ to year t, and scaled by the lagged total assets. LCF (FCF) is the lag (forward) of cash flow, $\Delta SALES$ is the sales growth, computed by Δlog(total revenue), and FA is fixed assets, scaled by the total assets.

The estimation of the extended FDD model follows two steps. First, we estimate the equation (13). Next, we calculate the standard deviation of the firm's regression residuals over the five years, i.e. $\epsilon_{i,t}$ through $\epsilon_{i,t-4}$. We use this standard deviation as a proxy for information asymmetry ($INFASY$) in the regression model (12). The larger standard deviations of residuals reflect that there are a greater portion of the current accruals unexplained by the extended FDD model, which indicates poorer accruals quality.

We estimate the equation (12) for the financially constrained firms identified by firm size in the SS group. The estimate of β_3 is significant and negative (−7.16) in the first column of Table 2.[12] The one-tailed t-test result for the null hypothesis of $H_0 : \beta_3 \geq 0$ also supports the statistical significance of our theoretical prediction by rejecting the null hypothesis at the 1% level. Therefore, we can confirm that the strong substitutable relationship in the financially constrained firms is identified by the pecking order theory.

[Table 2 about here.]

5.2.2 Capital adjustment cost

We however find that the estimate of β_3 is insignificant and the null hypothesis of $H_0 : \beta_3 \geq 0$ is not rejected for the financially unconstrained firms as seen in the second column of Table 2. Thus, we cannot explain the strong substitutable relationship for the financially unconstrained firms using the pecking order theory.

To fill this blank space in the SS group, we test the adjustment cost arguments suggested by Strebulaev (2007) for financially unconstrained firms. According to the adjustment cost arguments, we should observe that firms with higher adjustment costs show a stronger substitutable relationship.

[12] The estimate of β_1 is negative and significant. This captures the substitutable relationship between internal funds and external financing. In all groups, we find that the estimate of β_1 is consistent with the relationship.

Therefore, in the following regression model,

$$DEBT = \beta_0 + \beta_1 CF + \beta_2 ADJCOST + \beta_3 ADJCOST \cdot CF + Firms + Industry + Year + \epsilon, \tag{14}$$

β_3 should be negative.

The variable $ADJCOST$ denotes the variable of adjustment cost in the regression model. We follow the spirit of Dittmar and Mahrt-Smith (2007) and estimate the value of change in debt in the following regression:

$$\begin{aligned} R - R^B = {} & \gamma_0 + \gamma_1 \Delta DEBT + \gamma_2 \Delta DEBT^2 + \gamma_3 \Delta EBITDA + \gamma_4 \Delta NA + \gamma_5 \Delta RD + \gamma_6 \Delta IE + \gamma_7 \Delta DIV \\ & + \gamma_8 LCASH + \gamma_9 LEV + \gamma_{10} NF + \gamma_{11} \Delta CASH + Firm + Industry + Year + \epsilon, \end{aligned} \tag{15}$$

where Δ indicates a change in variables from year $t-1$ to t and the variables are scaled by the market value at year $t-1$. The dependent variable is the stock return over year $t-1$ to t, R, minus the return on a benchmark portfolio (market return here), R^B. Independent variables include debt ($DEBT$), earnings before interest and extraordinary items ($EBITDA$), net assets (NA), R&D expenditure (RD), interest expenses (IE), dividend (DIV), the lagged cash holding ($LCASH$), leverage (LEV), and net financing (NF) during a fiscal year. We control firm, industry, and year fixed effects. Using this specification, we compute the cost of debt as follow:

$$\widehat{COST} = -0.044 \Delta DEBT + 0.352 \Delta DEBT^2, \tag{16}$$

and we use it as a proxy for the firm's adjustment cost.[13]

We estimate the equation (14) for the financially unconstrained firms identified by firm size in the SS group and test the null hypothesis of $H_0 : \beta_3 \geq 0$. The estimate of β_3 is negative (-1.57) in the third column of Table 2. The one-tailed t-test result also supports the statistical significance of our theoretical prediction by rejecting the null hypothesis at the 1% level. Therefore, we can confirm that the strong substitutable relationship in the financially unconstrained firms is identified by the adjustment cost channel.

5.2.3 Liquidity channel

The liquidity arguments explain the weaker substitutable relationship for those firms to use the rest of internal funds to raise cash holdings for smoothing the future investment process rather than to

[13]We find that the coefficient on $\Delta DEBT$ is not significant. Thus, we also compute the cost without this term and run the same test. We find the consistent results.

reduce external financing (Riddick and Whited, 2009; Bates et al., 2009; Bolton et al., 2011). Thus, if the firms use more internal funds to accumulate cash, the substitutable relationship would be weaker. Therefore, in the following regression model,

$$DEBT = \beta_0 + \beta_1 CF + \beta_2 LIQUID + \beta_3 LIQUID{\cdot}CF + Firms + Industry + Year + \epsilon, \tag{17}$$

β_3 should be positive since β_1 is negative.

The variable $LIQUID$ denotes the firm's liquid assets. We use the firm's cash holding scaled by the lagged total assets as a proxy for the liquid assets. We estimate the equation (17) with firms in the WC group and test $H_0 : \beta_3 \leq 0$ using the one-tailed t-test. The estimate of β_3 is positive (0.191) in the fourth column of Table 2. The positive sign is consistent with our theoretical prediction, but the null hypothesis ($H_0 : \beta_3 \leq 0$) is not rejected. When we focus only on financially constrained firms, the positive coefficient gets support by rejecting the null hypothesis at the 10% level (see the fifth column of Table 17). Therefore, although the statistical significance is not strong, we can still confirm that the weak substitutable relationship can be identified by the liquidity channel.

5.2.4 Credit multiplier channel

The credit multiplier arguments explain the complementary relationship. According to the arguments, the firm directs internal funds toward incremental investment, which increases its tangible assets. These create new collateral, which the firm can use to attract more external financing. Thus, if the firms hold more tangible assets, the complementary relationship would be stronger. Therefore, in the following regression model,

$$DEBT = \beta_0 + \beta_1 CF + \beta_2 TANGIBLE + \beta_3 TANGIBLE{\cdot}CF + Firms + Industry + Year + \epsilon, \tag{18}$$

β_3 should be positive.

The variable $TANGIBLE$ denotes the firm's tangible assets. We use the firm's fixed assets as a proxy for the tangible assets. We estimate the equation (18) with firms in the WC and SC groups, respectively, and test $H_0 : \beta_3 \leq 0$ using the one-tailed t-test. The estimate of β_3 is positive (0.619) and the null hypothesis of $H_0 : \beta_3 \leq 0$ is rejected at the 1% significance level in the WC group. It is also positive at 0.801 and the null hypothesis is rejected at the 10% significance level in the SC group (see the last column of Table 2). Therefore, we can confirm that the complementary relationship can be identified by the credit multiplier channel.

Overall, the four relationships proposed to test our hypotheses are well identified by our theoretical channels. Therefore, we can test our hypotheses based on the relationship between internal funds and external financing without the concern about whether each relationship is identified by the theoretical channels we proposed.

5.3 Baseline model results

Table 3 presents the results of baseline regression in equation (10). As a benchmark, we also run the regression without the interaction term ($CF \cdot CFVOL$). The results are consistent when different estimation periods of cash flow volatility are adopted. Taking column (1) as an example, the impact of cash flow volatility ($CFVOL$) on investment is significantly negative, which is in line with the predictions of real option theory (Dixit and Pindyck, 1994) and findings of existing empirical literature (Minton and Schrand, 1999). However, its magnitude is very small (-0.0004) compared to that of cash flow (0.0956). In terms of marginal effect, one standard deviation change in cash flow results in 0.0089 change in investment whereas the effect of one standard deviation change in the cash flow volatility is -0.0015 which is merely 2% of average investment rate. Hence, the rise of cash flow uncertainty is unlikely to be the dominant factor explaining the rapid slowdown in corporate investment in China in the post-GFC.

However, we find that cash flow uncertainty significantly affects investment through an indirect channel of *ICFS*. The estimated $ICFS_{\sigma}$, i.e. the coefficient of the interaction term ($CF \cdot CFVOL$), is -0.0662, which is much larger than the direct effect (-0.0003) and corresponds to the half of *ICFS* estimate (0.1130), in terms of absolute value. In terms of marginal effect, one standard deviation increase in the cash flow volatility decreases *ICFS* by 0.250 whereas one standard deviation change in the interaction term have an impact of -0.0232 on investment, which is about 35% of average investment rate. In brief, our results show that cash flow uncertainty has a large negative impact on firm's investment through the *ICFS* channel, i.e. cash flow uncertainty decreases the response of investment to cash flow (*ICFS*) which further dampens investment. Moreover, it is the rising cash flow uncertainty that explains the declining *ICFS* in China.

[Table 3 about here.]

This interesting result contradicts with the conventional financial constraint interpretation of *ICFS*, which motivates us to further examine how cash flow uncertainty affects investment along with ways of financing. In Table 4, we test Hypothesis 1 − 3 by identifying a relationship between internal funds (cash flow) and external financing (debt). We first estimate a correlation between cash flow and debt using the method discussed in Section 4.1 and then divide firms into four groups: SS, WS, WC, and

SC. For each group, we estimate the baseline regression (10) and test the three hypotheses[14]. First, we test Hypothesis 1 using the sample of the SS group, i.e. $H_0 : ICFS = 0$ and $H_0 : ICFS_\sigma = 0$. Despite the negative coefficient of both *ICFS* (-0.013) and $ICFS_\sigma$ (-0.097), they are both insignificant. Therefore, Hypothesis 1 is statistically valid in the SS group while being rejected in other groups, suggesting that there is zero *ICFS* and no impact of cash flow volatility on *ICFS* when there exists strong substitutable relationship between cash flow and debt.

[Table 4 about here.]

Next, in order to test Hypothesis 2 and 3, we apply the one-tailed t-test to the remaining three groups and test $H_0 : ICFS \leq 0$ and $H_0 : ICFS_\sigma \geq 0$. If the two hypotheses are valid, we should reject each given null hypothesis. Indeed, we find that the null hypotheses are rejected at the 5% significance level in all three groups, proving that Hypothesis 2 and 3 are statistically significant. Therefore, when the relation between cash flow and debt is weak substitutable or complementary, there exists positive *ICFS* and negative effect of cash flow volatility on *ICFS*. We also find that the positive *ICFS* and negative $ICFS_\sigma$ become stronger as the relation between cash flow and debt becomes more complementary, as predicted by Hypothesis 3.

5.4 Extended model results

Despite our efforts to control latent effects using firm, industry, and year fixed effects in the baseline model, there remains the potential problem of uncontrolled heterogeneity. We consider various control variables that are commonly used in the investment literature and introduced in the extended model (2) and test the hypotheses in the same way as the baseline model.

[Table 5 about here.]

In Table 5, we find consistent results with those of the baseline model and the results of control variables are largely in line with our predictions. Our hypotheses are well supported by the sample of Chinese listed firms in the extended model. The main differences between the extended model results and the baseline model results are that the sensitivity to Tobin's Q is weaker as a result of inclusion of both measures for Q (such as *RET* and *MARGIN*), but *ICSF* or $ICFS_\sigma$ become stronger. Thus, the inclusion of other control variables improves the significance of test result of all three hypotheses. Overall, we can confirm that our hypotheses about the impact of cash flow volatility on corporate investment are well supported by the sample of Chinese listed firms.

[14]Since our results are robust to the change of estimation period for the cash flow volatility, we mainly report the results based on the 3-year estimation period. Results based on other estimation periods are consistent and available upon request.

6 The Exogenous Shock Analysis

We measure cash flow volatility using the past cash flow, and use it as a proxy for cash flow uncertainty in the regression analysis. But there are two empirical issues. The first problem is measurement error because the cash flow volatility is the proxy for cash flow uncertainty, that is, the endogeneity problem occurs. Second, the cash flow volatility is likely to be correlated with the current cash flow due to the autocorrelation of cash flow, that is, the multicollinearity problem occurs. We aim to identify an exogenous historical event in the sample period which leads to a regime change in cash flow uncertainty, so that we can test our hypotheses without including the cash flow volatility in the regression model.

6.1 The impact of global financial crisis (GFC)

The most notable historical event in the past two decades is the GFC, which started from the bursting of the US housing bubble and culminated with Lehman Brothers' bankruptcy on September 15, 2008. The GFC caused the US firms to experience the most direct downturn. The Chinese economy was also hit dramatically by the GFC. The rate of economic growth dropped sharply in the final quarter of 2008 and the stock market lost three-quarters of its value by the end of 2008. Chinese firms suffered from sharply rising cash flow uncertainty. As is shown in the Figure 1, this event causes a significant cash flow shortfall to all firms, and their cash flow volatility has increased dramatically since 2008 while their *ICFS* has decreased significantly. It also casts a 'long shadow' on Chinese economy (Bai et al., 2016). Consequently, the increased cash flow uncertainty by the GFC brought about the structural change in *ICFS*, and this change is consistent with our theoretical arguments. Therefore, considering the GFC as a structural breakpoint where the regime of cash flow uncertainty jumps from low to high is a reasonable choice.

We consider a simple single structural change model to test the structural change of *ICFS* after the 2008 GFC:

$$INV = \beta_0 + \beta_1 Q + \beta_2 CF + (\delta_0 + \delta_1 Q + \delta_2 CF)D_{Post} + \gamma' X + Firm + Industry + Year + \epsilon, \qquad (19)$$

where D_{Post} is a dummy variable taking a value of 1 for Year>2008 and 0 otherwise. Our Hypothesis 1 implies that β_2 (i.e. $ICFS$) = 0 and δ_2 (i.e. $\Delta ICFS$) = 0 for the SS group. In other words, *ICFS* is zero before the GFC and there is no change in *ICFS* after the GFC. For our Hypothesis 2 and 3, $\beta_2 > 0$ and $\delta_2 < 0$ for the other three groups. That is, *ICFS* is positive in the pre-GFC, and *ICFS* decreases as cash flow uncertainty increases in the post-GFC. Therefore, for our Hypothesis 1, we test $H_0 : ICFS = 0$ and $H_0 : \Delta ICFS = 0$ with samples in the SS group. For our Hypothesis 2 and 3, we test $H_0 : ICFS \leq 0$ and

$H_0 : \Delta ICFS \geq 0$ with samples in the other three groups, respectively.

However, the GFC is likely to affect not only cash flow uncertainty but also the relationship between internal funds and external funds. To control this possibility, we select only firms whose relationships remain unchanged after the GFC. According to the correlations before and after the GFC, 35% of firms stay in the same category. Table 6 presents the estimation and testing results by the single structural change specification.

[Table 6 about here]

First, the test results for the SS group statistically support Hypothesis 1. Second, *ICFS* is positive and significant in the other three groups, and the stronger the complementary relationship, the more sensitive *ICFS* is. This pattern is consistent with Hypothesis 2 and 3. The change of *ICFS* after the GFC is negative for all three groups. Consistent with our predictions, the magnitude of reduction increases as the complementary relationship becomes stronger. The p-values for testing $H_0 : \Delta ICFS \geq 0$ are also $4.6\% - 5.4\%$. Consequently, we find acceptable evidence for the three Hypotheses based on the sub-sample analysis of Chinese listed firms. Further study is required to consider other shocks in the same period and their heterogeneous impacts on different types of firms.

6.2 The impact of 4-trillion stimulus package

Shocked by the speed and depth of the economic downturn, the Chinese government launched a 4 trillion RMB economic stimulus package in November 2008. Bank lending increased at an explosive pace since the announcement of stimulus efforts (Naughton, 2009). Despite its effectiveness in boosting domestic investment, the economic stimulus worsens the problem of soft budget constraint and reverses the flow of resources between the state and private sectors (Song and Xiong, 2018). The stimulus affects firms' cash flows through two channels: credit expansion and fiscal expansion. First, credit allocation favours SOEs and other connected private firms through explicit or implicit guarantees, which can be seen by the dramatic increase in the debt of local governments and listed firms, most of which are SOEs and connected private firms (Bai et al., 2016). Deng et al. (2020) find that the stimulus package adversely affects listed firms' investment activity and efficiency, and government-intervened firms substantially invest more compared to control firms. Cong et al. (2019) claim that the economic stimulus package, by allocating new bank credit disproportionately to SOEs and firms with lower average product capital, reverses the positive trend of capital reallocation towards private firms and dampens long-term growth prospects in China. It is the implicit government guarantee that makes banks favour SOEs more during recessions when the risk of financial distress rises. Second, Bai et al. (2016) suggests that the stimulus program channels fiscal resources toward low-productivity firms, but local-government favored private firms, with potentially negative effects on the efficiency of capital allocation. This explains the decline in profitability of private firms. On the other hand, SOEs are less affected by the GFC as the result of support and subsidy from the stimulus package in the post-GFC.

We examine how this economic policy affects the impact of cash flow uncertainty on the *ICFS* of SOEs after the GFC. Figure 8 shows that starting from a similar low level of CFSD in the pre-GFC, the rise of CFSD is much bigger for non-SOEs than for SOEs in the post-GFC. Figure 9 shows that in 2004, the *ICFS* maintained a similarly high level in both groups. Before the GFC, non-SOEs quickly decreased their dependence on cash flows, but SOEs remained at a high level of *ICFS*. As a result of the GFC, both groups suffered an unexpectedly sharp drop in cash flow in 2009, with more than half of the decrease compared to 2004. However, since non-SOEs had already reduced their dependence on cash flows significantly, *ICFS* stabilized at levels around 0.14 without significant fluctuation. On the other hand, since SOEs were unable to reduce their previous high cash flow dependence drastically, *ICFS* converged to the non-SOEs level after two modifications (2009-2013; 2013-2016), as reflected by the average *ICFS* trends in the figure.

[Figure 8 about here]

[Figure 9 about here]

Therefore, we isolate the effect of stimulus package on SOEs from the whole sample and adopt the following difference-in-difference type model:

$$\begin{aligned} INV = {} & \beta_0 + \delta_0 D_{Post} + \gamma_0 D_{SOE} + \pi_0 D_{Post} \cdot D_{SOE} \\ & + \beta_1 Q + \delta_1 Q \cdot D_{Post} + \gamma_1 Q \cdot D_{SOE} + \pi_1 Q \cdot D_{Post} \cdot D_{SOE} \\ & + \beta_2 CF + \delta_2 CF \cdot D_{Post} + \gamma_2 CF \cdot D_{SOE} + \pi_2 CF \cdot D_{Post} \cdot D_{SOE} \\ & + \gamma' X + Firm + Industry + Year + \epsilon, \end{aligned} \tag{20}$$

where D_{SOE} is a dummy variable taking a value of 1 for SOEs and 0 for non-SOEs. In the regression, β_2 indicates *ICFS* for non-SOEs during the pre-GFC and δ_2 indicates the change of *ICFS* from the pre-GFC to post-GFC for non-SOEs. We apply the same tests to these two parameters for all subgroups. Also, $\beta_2 + \gamma_2$ indicates *ICFS* for SOEs during the pre-GFC and $\delta_2 + \pi_2$ indicates the change of *ICFS* from the pre-GFC to the post-GFC for SOEs. Table 7 presents the estimation and testing results by the Difference-in-Difference (DID) specification in (20).

[Table 7 about here]

First, we take a look at the estimation results. For both SOEs and non-SOEs, $ICFS$, i.e. β_2 and $\beta_2 + \gamma_2$, has a positive value for the other three groups, except for the SS group, and shows a more sensitive response as the complementary relationship tightens. This finding is consistent with our theoretical prediction on $ICFS$. Second, we look at the changes of $ICFS$ after the GFC. The $ICFS$ of non-SOEs decreases during the post-GFC, and the magnitude of reduction increases as the complementary relationship becomes stronger. This finding is also consistent with our theoretical prediction. However, as opposed to non-SOEs, we find the reduction of $ICFS$ for the substitutable relationship and the increase for the complementary relationship.

Next, we take a look at the test results. For the SS group, we cannot reject both zero $ICFS$ and zero $\Delta ICFS$ at the 5% significance level. The positive $ICFS$ is also statistically supported for the other three groups. However, $H_0 : \Delta ICFS \geq 0$ is rejected for only non-SOEs at the 5% significance level. The hypothesis is not rejected for all the three groups even at the 10% significance level. These test results show that the results are superior to the previous results where SOEs are not isolated from non-SOEs in the regression.

In sum, after we control for the impact of the government's economic stimulus policy on SOEs in the post-GFC, we find more consistent results with our theoretical predictions using the exogenous shock of the GFC on the cash flow uncertainty in the DID specification.

7 Robustness Analysis

In this section, we examine various empirical issues that could affect the results of testing our theoretical hypotheses, which include (i) downside risk, (ii) stock return based uncertainty measure, and (iii) measurement error in Q.

7.1 Downside risk

Some firms are much more sensitive to negative cash flow shocks than to positive shocks, because the negative cash flow shocks are directly linked to the firm's cash flow shortfall, affecting its investment. Therefore, the downside cash flow volatility could be a more suitable measure for testing our hypothesis than the standard volatility used in our main test. We estimate the extended regression in equation (11) with the downside cash flow volatility in equation (9) and test the three hypotheses. We report all the test results in Table 8. Although the downside cash flow risk is closely related to the firm's cash flow shortfall for some firms, both estimation and testing results are hardly changed by the downside risk compared to Table 4. It is hard to say that the downside cash flow volatility is the more appropriate proxy for the cash flow uncertainty, but it must be a reliable proxy for the cash flow uncertainty.

[Table 8 about here.]

7.2 Stock return based uncertainty measure

There is a debate of whether the accounting-based measure or the market-based measure is more appropriate as a proxy for the cash flow uncertainty. The accounting-based measure, such as the cash flow volatility used in our empirical analysis, may not convey long-term information about the future cash flow uncertainty because it is based on information that has occurred to date. Thus, the cash flow volatility may not necessarily be the optimal forecast of the firm's cash flow uncertainty. By contrast, the stock return volatility is a market-based measure. Despite the use of past stock prices for estimation, the stock price reflects the expectation for the firm's future cash flows in principle.[15] Therefore, it could be more advantageous than the cash flow volatility in the efficient market universe.

We estimate the extended regression in equation (11) with the stock return volatility and test our three hypotheses. We report all the test results in Table 9. When there is the substitutable relationship between internal funds and external financing, Hypothesis 1 and 2 are not rejected, the same result as when the cash flow volatility is used. These results are found to be the same for both $SYSVOL$ and $FIRMVOL$ as well. However, when the relation is complementary, the test results no longer support Hypothesis 3. In the case of weak complementarity, the first null hypothesis, i.e. $H_0 : ICFS \leq 0$, is rejected, but the second null hypothesis, i.e. $H_0 : ICFS_\sigma \geq 0$, is rejected at the 5% significance level for $SYSVOL$ only. In the case of strong complementarity, the first null is rejected at the 10% significance level, but the second null hypothesis is not rejected for all of three volatility measures, i.e. $ICFS_\sigma$ is significantly positive.

[Table 9 about here.]

In sum, the test results using the stock return volatility are not consistent with those using the cash flow volatility. In particular, credit multiple arguments for the complementary relationship are no longer valid. These results imply that the stock return volatility conveys different information from the cash flow volatility.[16] It does not mean that the cash flow volatility is generally a more appropriate proxy for the cash flow uncertainty than the stock return volatility. However, considering the inefficiency of the Chinese stock market, the cash flow volatility could be a more reliable measure than the stock return volatility in China.

[15] See the recent work about firm uncertainty by Easterwood et al. (2021)

[16] The correlation between the two in each group are very low, with 0.003 (SS), 0.019 (WS), 0.035 (WC), and 0.002 (SC), respectively.

7.3 Measurement error in Q

Measurement error is the most prominent issue in the empirical study of the Q theory. This is especially the case for China where researchers find that a firm's investment does not significantly respond to the stock market valuation due to the inefficiency of the stock market (Wang et al., 2009; Guariglia and Yang, 2016). Investment-related literature has addressed this issue, and there have been significant methodological efforts to mitigate it in various ways. We adopt three widely-used approaches, namely the Erickson and Whited (2000, 2012) method, the Lewellen and Lewellen (2016) method and the alternative measure of investment opportunities using sales growth, to alleviate this problem.

First, many previous studies have used a lagged market-to-book (MB) or the change of MB. We also use the lagged MB as the instrument variable (hereafter IV) for MB in our empirical analysis. However, it does not consider further lagged MBs as possible IVs. Erickson and Whited (2000, 2012) develop a more systematic econometric approach. They adopt the GMM estimator, which uses higher-order moments as IVs. Their method requires a strong assumption that the sample should be i.i.d., which is easily rejected in the panel data. For this reason, its statistical inferences highly rely on the underlying probability law of the sample.

Second, we apply the approach of Lewellen and Lewellen (2016), two-stage least square (2SLS) estimator, to our study. In the first step, we regress MB for IVs, and the fitted value of MB replaces MB. In the second step, we estimate the extended model using the MB's fitted value and test our hypotheses. In the first step, we select cash flow and return as IVs for MB. MB's measurement error is mainly generated by book value. However, cash flow and return are related to the firm's market value, since cash flow is associated with profitability and stock price determined by its fundamental value. We first start with the current cash flow and the lagged return. Then we add the lagged cash flow and the further lagged return according to the explanatory variables' significance. In the case of cash flow, both current and lagged cash flow significantly explain MB. In the case of a return, we find significant explanatory power up to the third lagged return. Therefore, MB is fitted using current and lagged cash flow and returns up to 3 years in the past.

Lastly, we use sales growth as an alternative proxy to investment opportunities for the following reasons. First, it reflects a firm's fundamental value (Firth et al., 2008; Cull et al., 2015). Second, it is commonly used as the proxy to demand growth, and the state of demand often has a significant impact on the firm-level investment decision (Blundell et al., 1992; Bloom et al., 2007). Third, it is a more exogenous variable to measure investment opportunities since demand-side factors determine it (Love and Zicchino, 2006).

Table 10 reports the results. Panel *LL* reports the extended model's estimation and test results where the fitted MB replaces MB as in Lewellen and Lewellen (2016). Compared to the extended model analysis using the lagged MB, *ICFS* has increased in all groups. But this change occurs in neither cash flow volatility nor the interaction term. Panel *EW* reports the GMM results with the higher-order moments as IVs (Erickson and Whited, 2000, 2012). Like the result of *LL*, *ICFS* has increased in all groups. The results of last panel based on sales growth are consistent with those of *LL* and *EW* in general.

[Table 10 about here.]

Comparing to our extended model's results, we recognize the possible downward bias of *ICFS* because the estimates of *ICFS* consistently increase when we use alternative IVs or proxy. As a result, our test results are found to be of higher statistical significance than our previous results. Alternative IVs or proxy to *Q* allow us to decrease the potential biases caused by measurement errors, but the reduction does not change our previous statistical inferences on the theoretical hypotheses.

8 Further Tests with the US Data

Can we apply our theoretical hypotheses on the impact of cash flow uncertainty on *ICFS* to other countries and thus having more general implications? We choose the US, the world's largest economy with developed financial system, as an example for this purpose.

For US firms, fixed investment is no longer the main driver of growth like China, as shown in the summary statistics of the key variables with US data from 1999 - 2017 in Table 1. In Section 5.1, we have summarized that US firms invest less in tangible assets but more in R&D investment, compared with Chinese firms. The US firms rely as much on equity issuance as on debt when financing investment. Although the investment of US firms still positively respond to a cash flow shock, it is not as sensitive as the investment of Chinese firms. Figure 10 presents the *ICFS* and CFSD of US firms from 1999 to 2017. The average change before and after the GFC is similar to that of Chinese firms in *ICFS* and CFSD. However, their overall trends are very different from those of Chinese firms.

[Figure 10 about here.]

The *ICFS* remained at the average of 0.11 until 2008 but dropped sharply to 0.07 in 2009 due to the GFC. Since then, the government's QE policy and $787 billion stimulus has maintained its pre-GFC level but has declined since 2011 to 0.06. This figure is much lower than China's 0.15 in 2017. In contrast, CFSD remained at the average of 0.20[17] until 2008 and rose to the average of 0.24 during the

[17] Note that the average for Chinese firms over the same period was 0.11.

post-GFC. After the GFC, the CFSD of Chinese firms increased rapidly and then decreased to pre-GFC levels, while the CFSD of US firms continued to rise in the post-GFC. In particular, *ICFS* and CFSD in US firms since 2008 clearly show a negative relationship. These characteristics suggest that we can apply our theoretical hypotheses about the impact of cash flow uncertainty on *ICFS* to the US firms.

Table 11 presents both the estimation and test results for our theoretical hypotheses based on the extended model[18]. We first test Hypothesis 1 – 3 with the debt financing as we did for Chinese firms, and a panel *Debt* presents the results. The test results for the SS group strongly support Hypothesis 1. For the WS group, we manage to reject the two null hypotheses at the 10% significance level. Thus, statistical evidence for Hypothesis 2 is weak. However, the complementary groups' test results strongly support Hypothesis 3 at the 1% significance level. Additionally, we can observe the increasing pattern of *ICFS* and the decreasing pattern of $ICFS_{\sigma}$, respectively. Therefore, the statistical evidence for Hypothesis 2 is weak, but overall results are consistent with our theoretical predictions in the US firms as well.

[Table 11 about here.]

However, unlike Chinese firms, US firms have been actively using equity issuance along with debt. Equity financing is as attractive to firms as debt financing because the US stock market is mature and liquidity-rich. The data also clearly identifies this tendency of US firms. Figure 11 presents the average ratio of debt to total assets, the average ratio of equity issuance to total assets, and the proportion of firms using debt and equity issuance by year. The average debt ratio is 12%, which is 4% higher than the average equity ratio (8%). But the difference between two ratios is significantly lower than that of Chinese firms.[19] More importantly, this debt-to-equity ratio has remained almost constant over the past 20 years. In other words, US firms have continued to mix debt and equity at an appropriate level. Moreover, the average proportion of firms using equity is 82%, which is much higher than 51%, the average proportion of firms using debt. The balance between using debt and equity has remained stably over the past two decades. For these reasons, we should analyze both debt and equity to achieve meaningful results for the US firms.

[Figure 11 about here.]

The panel *Equity* presents estimation and test results using equity. It is generally consistent with the results using debt and more statistically supports our theoretical hypotheses. Especially for the WS group, we can reject the two null hypotheses at the 1% significance level. The panel *Debt and*

[18]Note that Table 5 reports the test results for Chinese firms based on the extended model.

[19]For Chinese firms, the average debt ratio is 26% and the average equity ratio is only 3%.

Equity presents estimation and test results using debt and equity together. Although not very strong overall, the test results statistically support all theoretical hypotheses at least at the 10% significance level. Consequently, our theoretical hypotheses about the impact of cash flow uncertainty on *ICFS* are also valid for the US firms.

9 Conclusion

In this paper, we provide a novel explanation of *ICFS* which reflects not only the information between investment and cash flow, but also the different relationship between internal funds and external financing. For firms that are profitable but face high costs of external financing, cash flow can directly relax their borrowing constraints. Under such circumstance when cash flow and debt are complements, high *ICFS* implies the high growth prospect of firms by mitigating their borrowing constraints and facilitating strong investment and fast growth. We find that cash flow uncertainty significantly decreases the *ICFS* especially for firms with stronger complementary relationship between cash flow and debt, which suggests that such firms are more sensitive to uncertainty shocks. Hence, a reduction in cash flow uncertainty can significantly boost these firms' investment and growth potential. These theoretical hypotheses are well supported by evidence from both China and the US, suggesting the applicability of our story to the general literature.

Our research provides insights on the reasons for China's high investment. In face of rising cash flow uncertainty, Chinese firms managed to obtain significant amount of debt to financing investment. This is a good news for the 'complement' group, which are the firms with high investment opportunity, cash flow and profitability. However, for the 'substitute group' which are mainly large and less profitable firms, high level of debt may indicate the presence of soft budget constraints and endanger investment efficiency in China.

Our results from the exogenous shocks provide evidence that the stimulus-driven credit and fiscal expansion in response to the GFC has disproportionately protected SOEs from the cash flow shocks, leaving the more productive non-SOEs being more adversely affected and resulting in a significant reduction of investment of non-SOEs through the ICFS channel. This has further worsened the investment efficiency in China after the GFC as the stimulus package has induced an investment shift from the more productive non-SOEs to the less productive SOEs.

Lastly, our paper has important implications on the impact of the recent pandemic. The economic uncertainty in China has sharply increased since COVID-19 was declared to be a pandemic by the

World Health Organization on 11 March 2020, as measured by China's daily ETF volatility index[20]. Our preliminary examination of the data shows that the liquidity channel discussed in this paper offers a good explanation of Chinese firm's investment under the pandemic uncertainty where cash flow is reserved in cash holding for future opportunities during the pandemic. This provides an excellent topic for future research by extending the basic idea of current study into the work related to the uncertainty triggered by the global pandemic.

[20]ETF refers to Exchange Traded Funds which are shares of trusts that hold portfolios of stocks designed to closely track the price performance and yield of specific indices.

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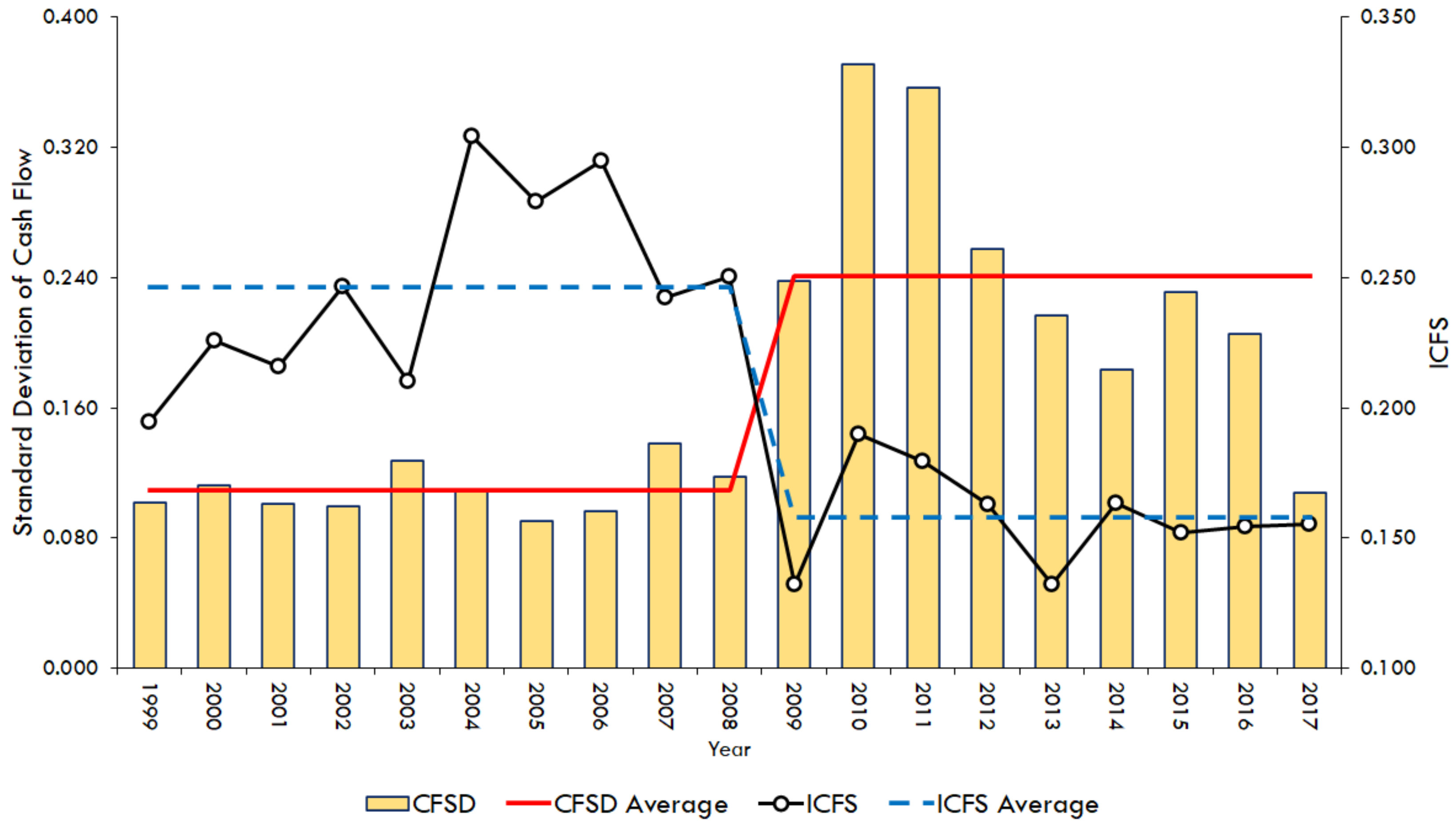

Figure 1: *ICFS* and Cash Flow Standard Deviation in China: 1999 – 2017

The figure plots *ICFS* and standard deviation of cash flow from 1999 to 2017. We estimate the cross-sectional regression of investment on q and cash flow for each year to get yearly *ICFS*. We also estimate the cross-sectional standard deviation of cash flow (CFSD hereafter) for each year to get yearly standard deviation. We then construct a time-series of *ICFS* and CFSD. Using the time-series, we calculate the average values of *ICFS* and CFSD for the pre- and post-GFC, respectively. *ICFS* Average (blue dash) and CFSD Average (red solid) plot the average values.

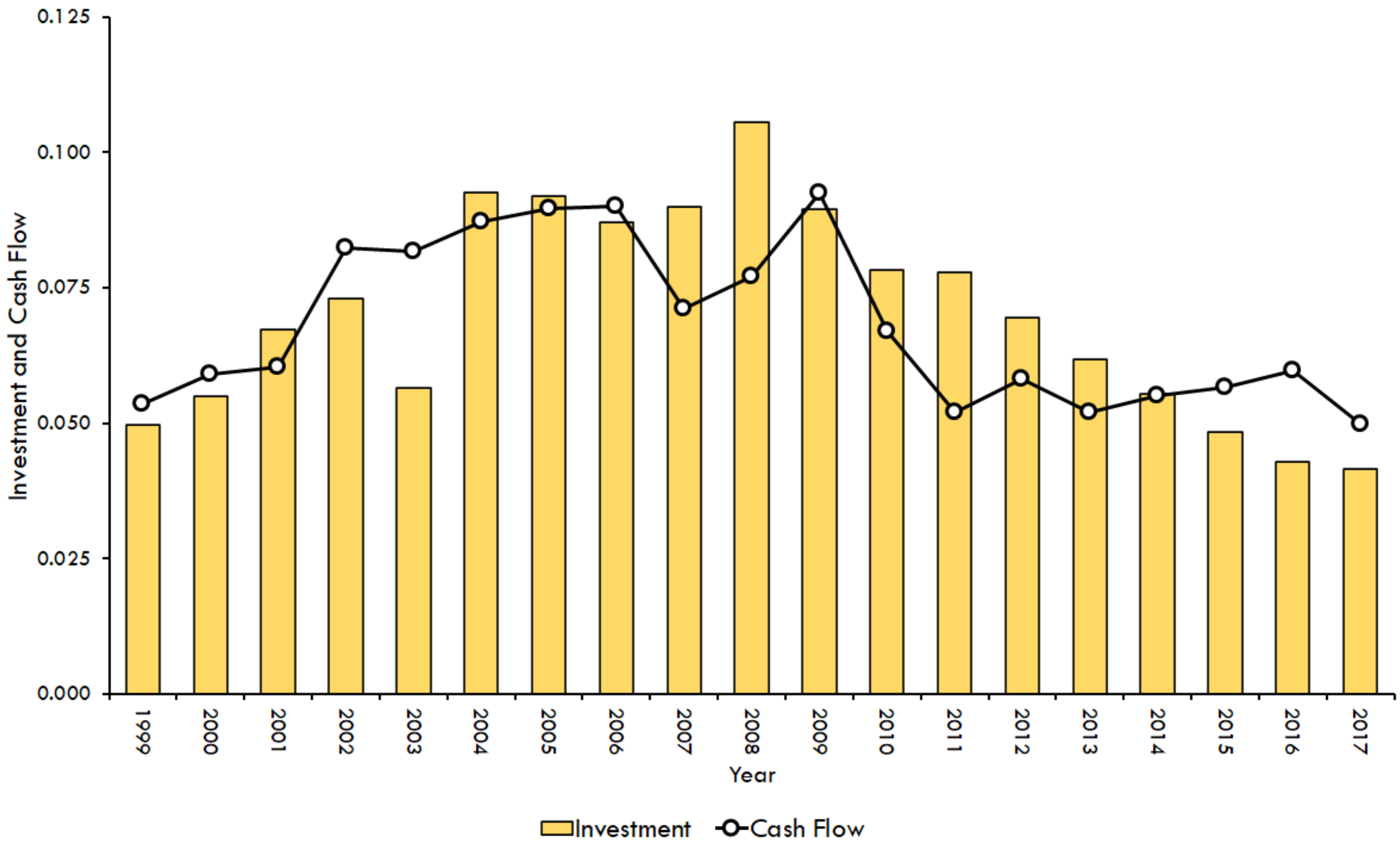

Figure 2: Aggregate investment and cash flow in China: 1999 – 2017

The figure plots aggregate values of investment and cash flow from 1999 to 2017. The aggregate values are measured by the sum of total capital expenditures and cash flow of the listed firms for each year. The year 1998 is missing because all aggregate variables are scaled by the lagged aggregate total assets. The correlation coefficient between investment and cash flow is 0.703.

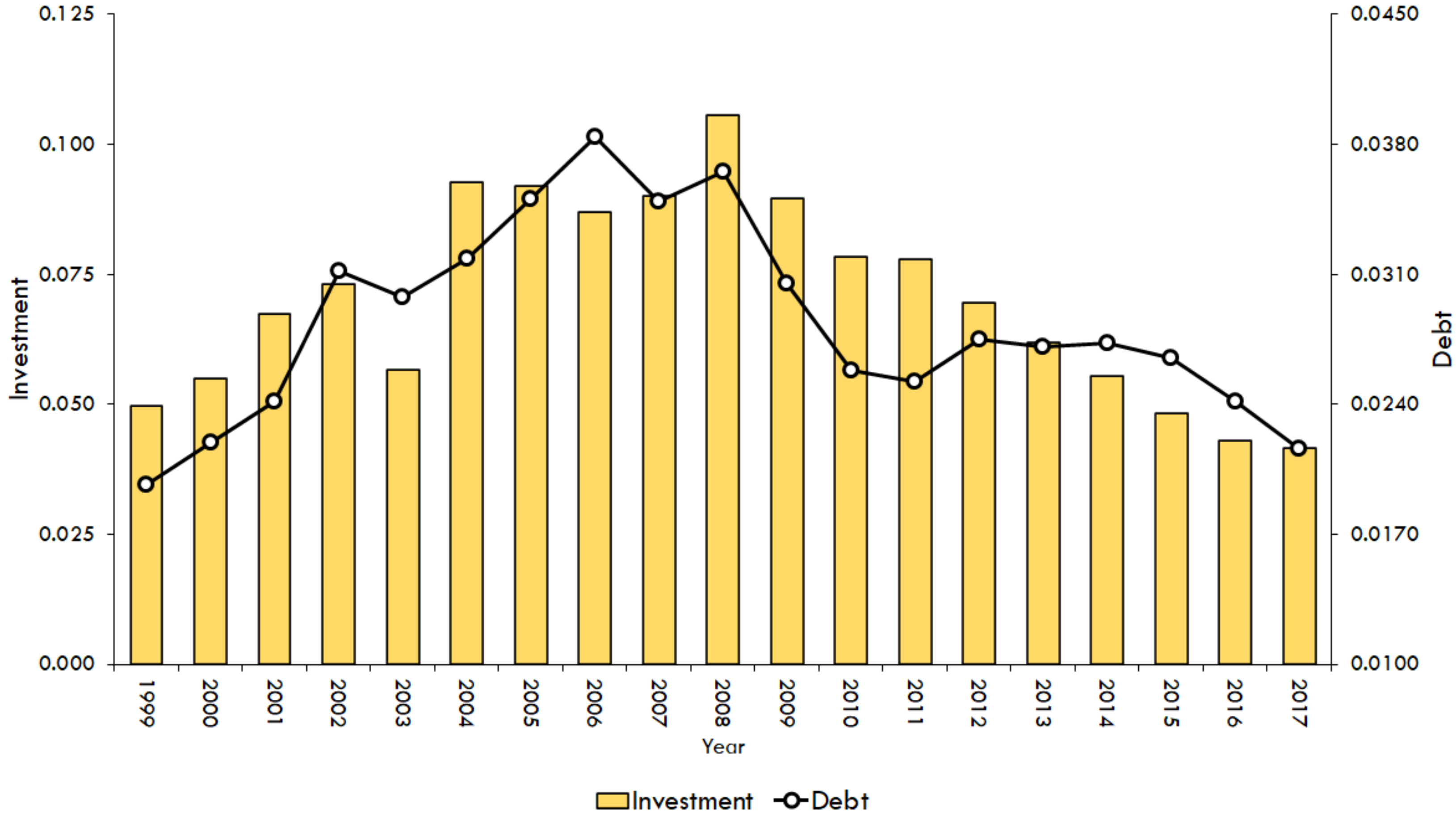

Figure 3: Aggregate investment and debt in China: 1999 – 2017

The figure plots aggregate values of investment and debt from 1999 to 2017. The aggregate values are measured by the sum of total capital expenditures and debt of the listed firms for each year. The year 1998 is missing because all variables are scaled by the lagged aggregate total assets. The correlation coefficient between investment and debt is 0.803.

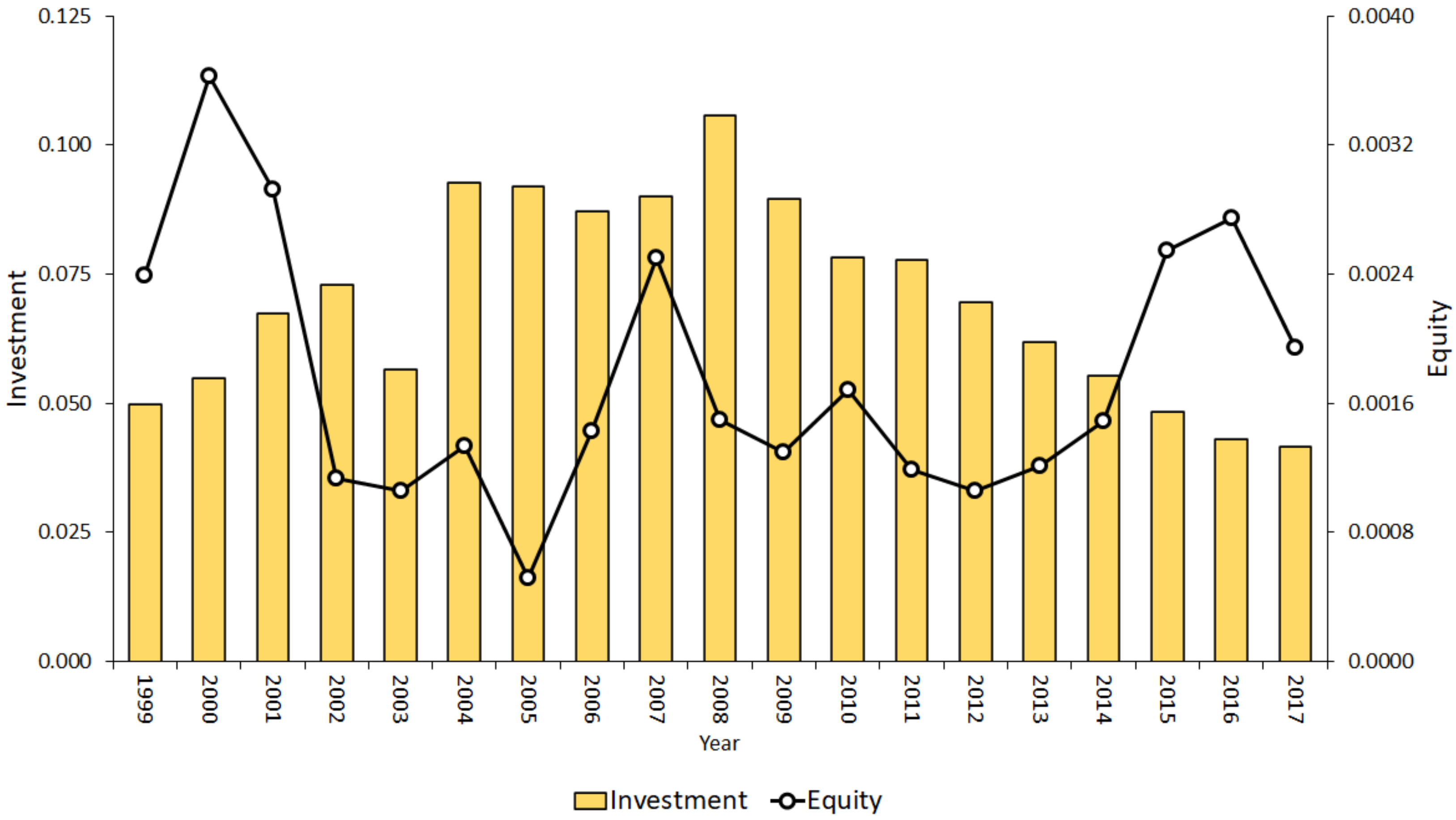

Figure 4: Aggregate investment and equity in China: 1999 – 2017

The figure plots aggregate values of investment and equity from 1999 to 2017. The aggregate values are measured by the sum of total capital expenditures and equity issues of the listed firms for each year. The year 1998 is missing because all variables are scaled by the lagged aggregate total assets. The correlation coefficient between investment and equity issue is −0.462.

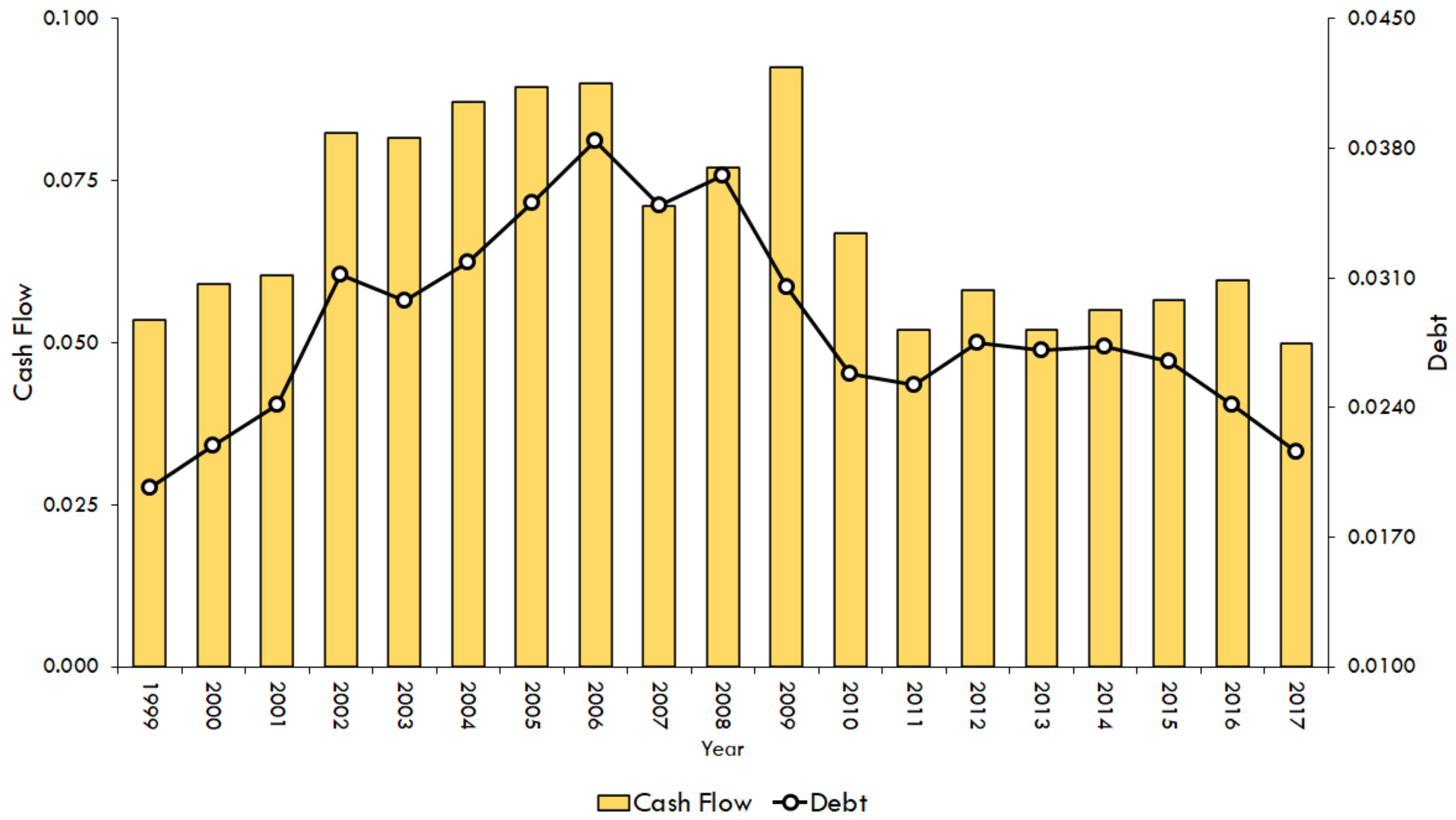

Figure 5: Aggregate cash flow and equity in China: 1999 – 2017

The figure plots aggregate values of cash flow and equity from 1999 to 2017. The aggregate values are measured by the sum of total cash flow and debt of the listed firms for each year. The year 1998 is missing because all variables are scaled by the lagged aggregate total assets. The correlation coefficient between cash flow and debt is 0.791.

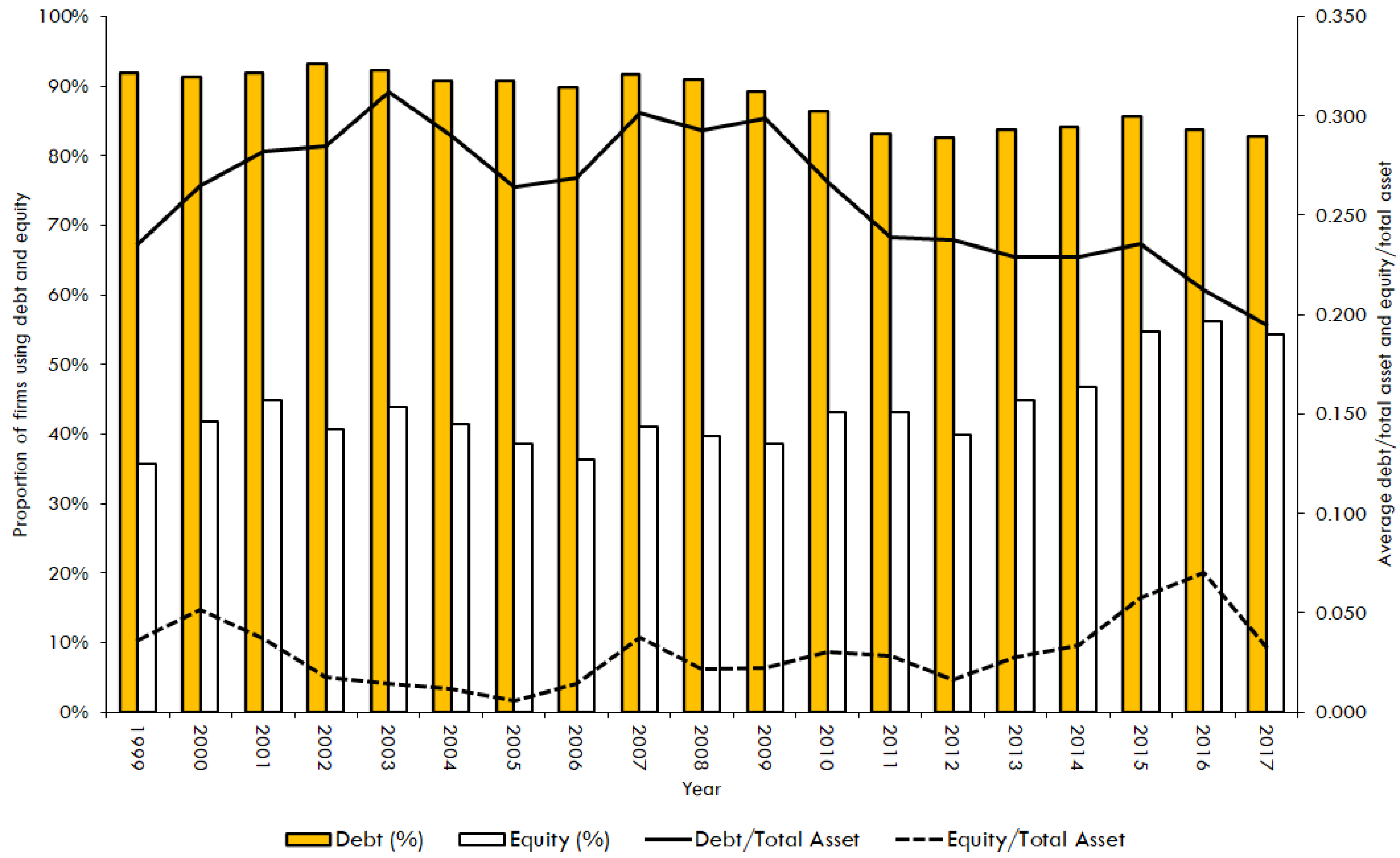

Figure 6: Debt and equity financing in China: 1999 – 2017

The figure plots the proportion of firms using debt and equity issuance and the cross-sectional average ratio of debt to total asset and equity issuance to total asset for each year from 1999 to 2017. The year 1998 is missing because both debt and equity issuance are scaled by the lagged total asset.

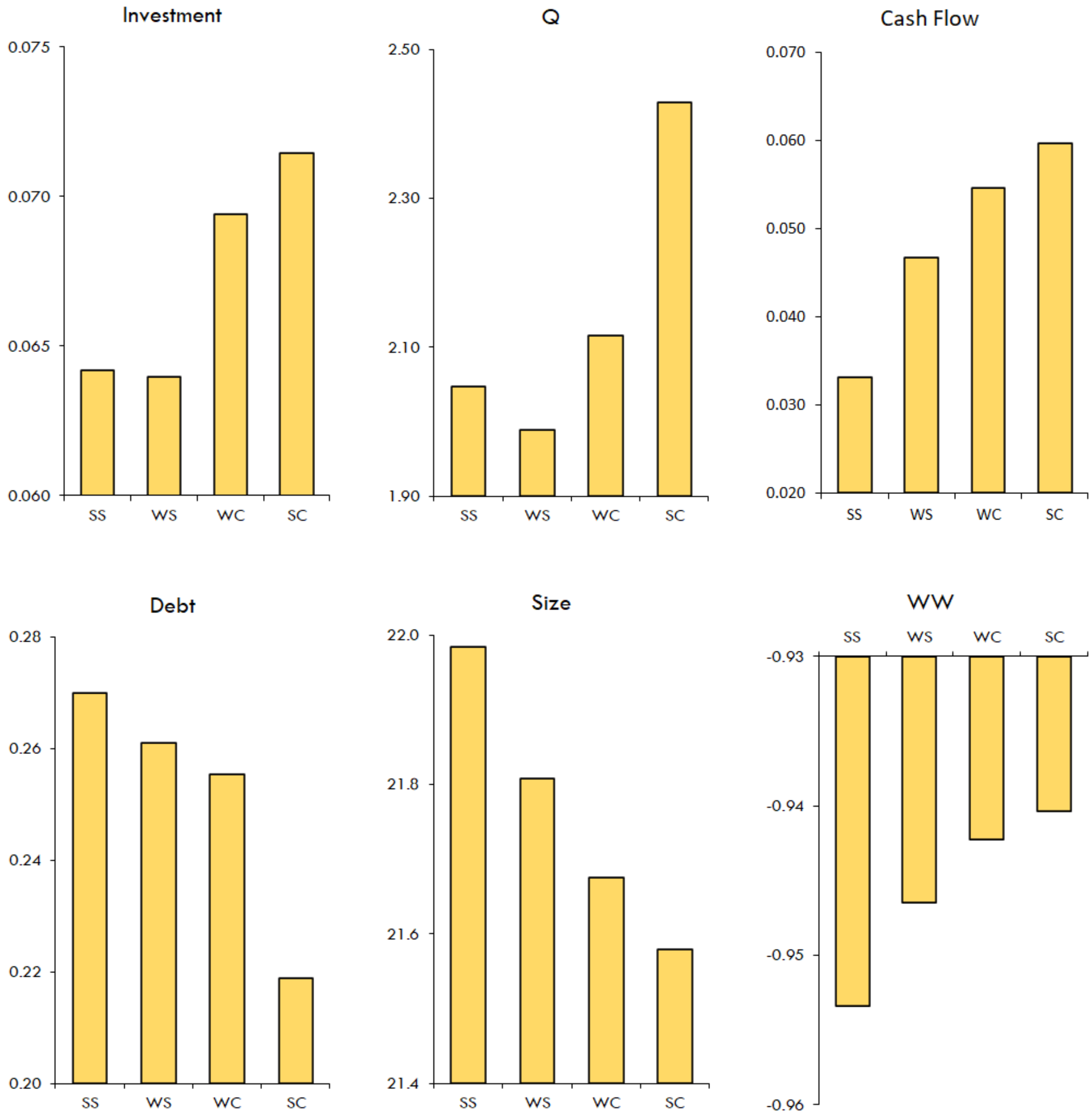

Figure 7: Investment, Q, Cash Flow, Debt, Size and WW in China

The figure plots mean values of investment, Tobin's Q, cash flow, debt, size and WW for each testing group divided by correlation coefficients between internal funds and external financing. Investment denotes capital expenditure. Cash Flow is the cash flow from operating activities. Debt is the proceeds of debt sales. All the variables above are scaled by the lagged total assets. Q is market-to-book ratio at the beginning of the year, which is the lagged market value over the lagged total asset. Size is the natural log of the total assets. WW is Whited-Wu index calculated following Whited and Wu (2006) and indicates financial constraints.

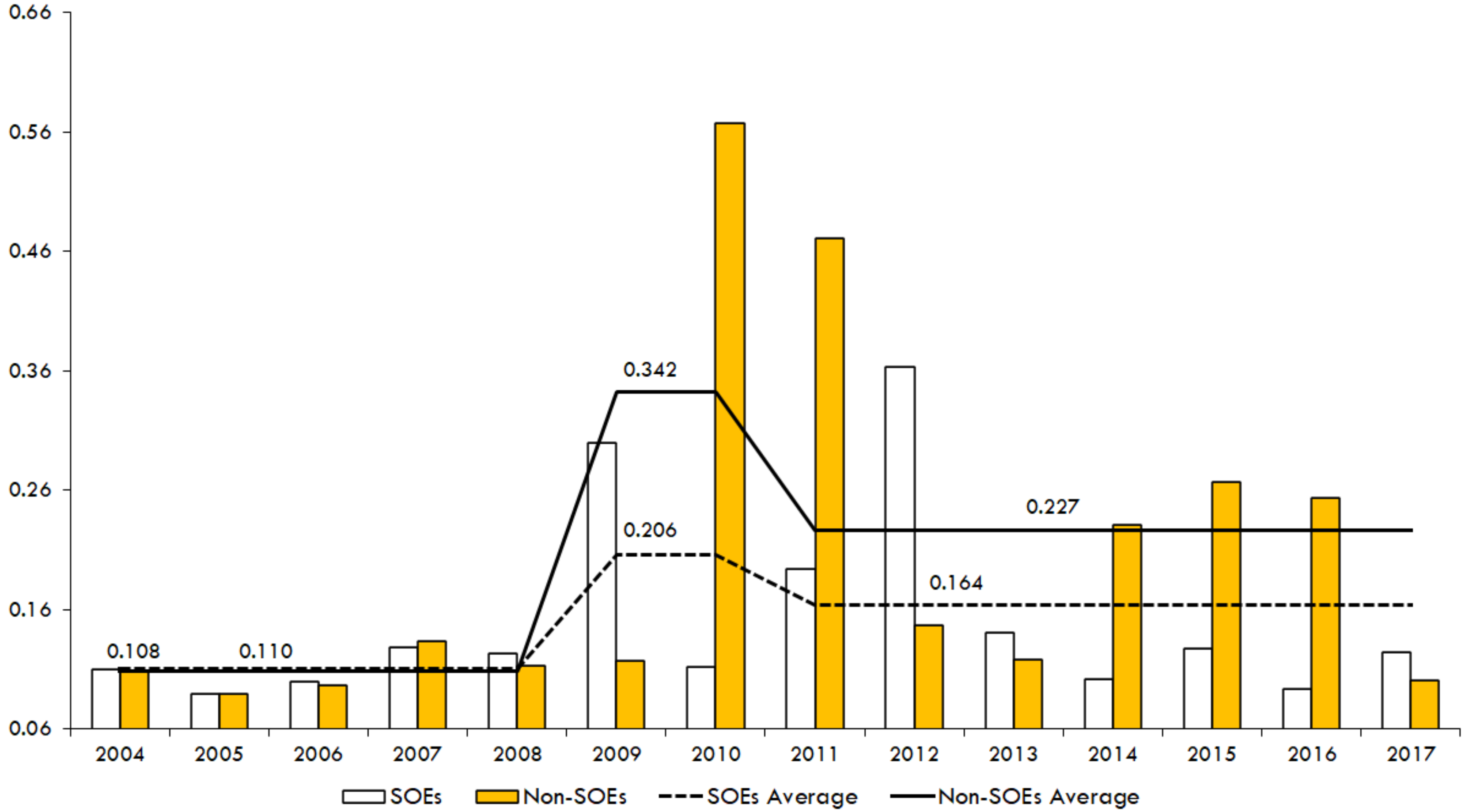

Figure 8: CFSD for SOEs and Non-SOEs in China: 2004 – 2017

The figure plots the cross-sectional standard deviation of cash flow (CFSD) for SOEs and non-SOEs from 2004 to 2017. We calculate average values for three sub-periods; 2004–2008, 2009–2010 and 2011–2017. The years before 2004 are missing because ownership information is available from 2004.

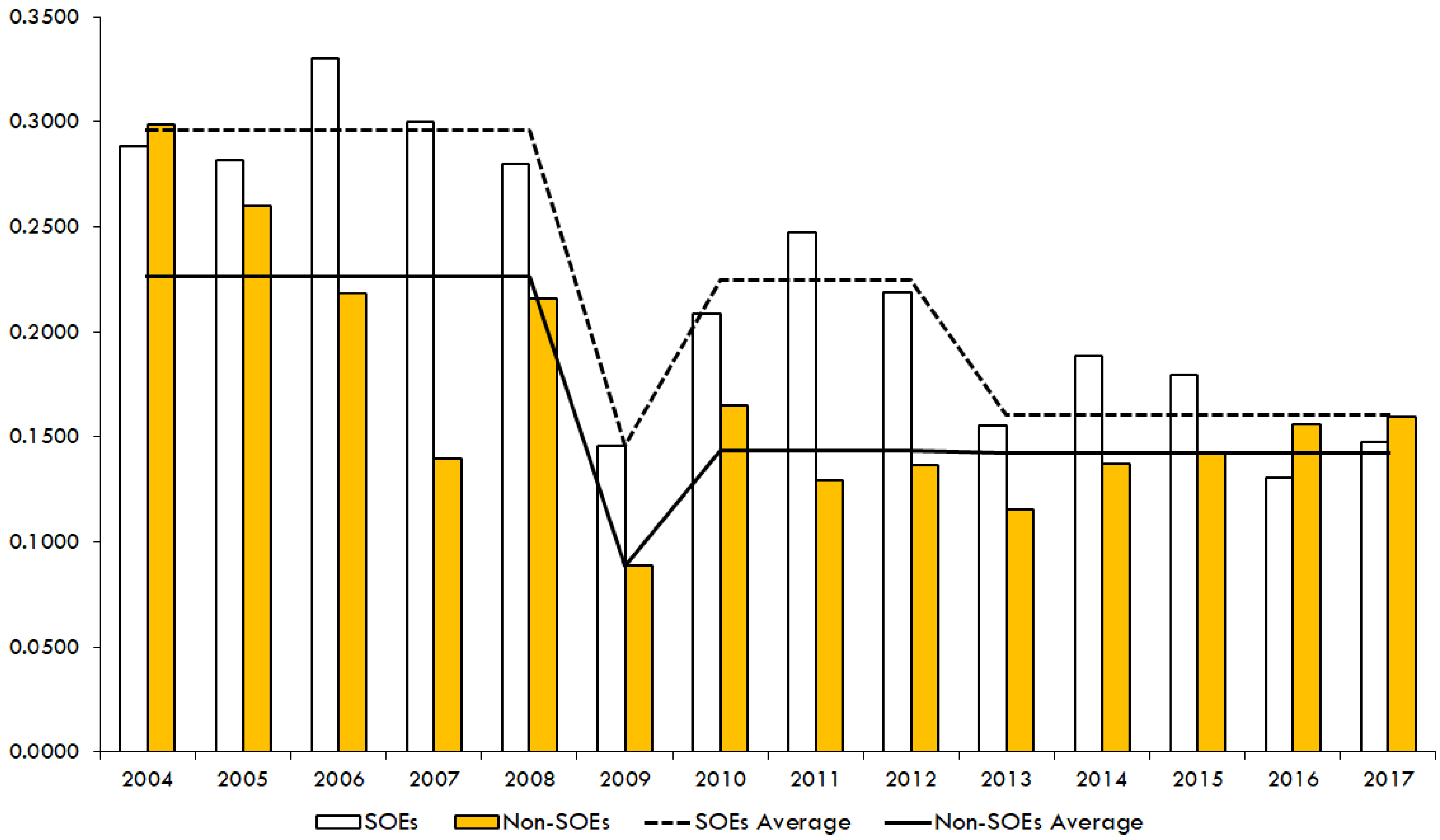

Figure 9: *ICFS* for SOEs and Non-SOEs: 2004 – 2017

The figure plots *ICFS* for SOEs and non-SOEs from 2004 to 2017. We estimate a cross-sectional regression of investment on Tobin's Q and cash flow separately for SOEs and non-SOEs every year. We calculate average values for three sub-periods; 2004–2008, 2009–2010 and 2011–2017. The years before 2004 are missing because ownership information is available from 2004.

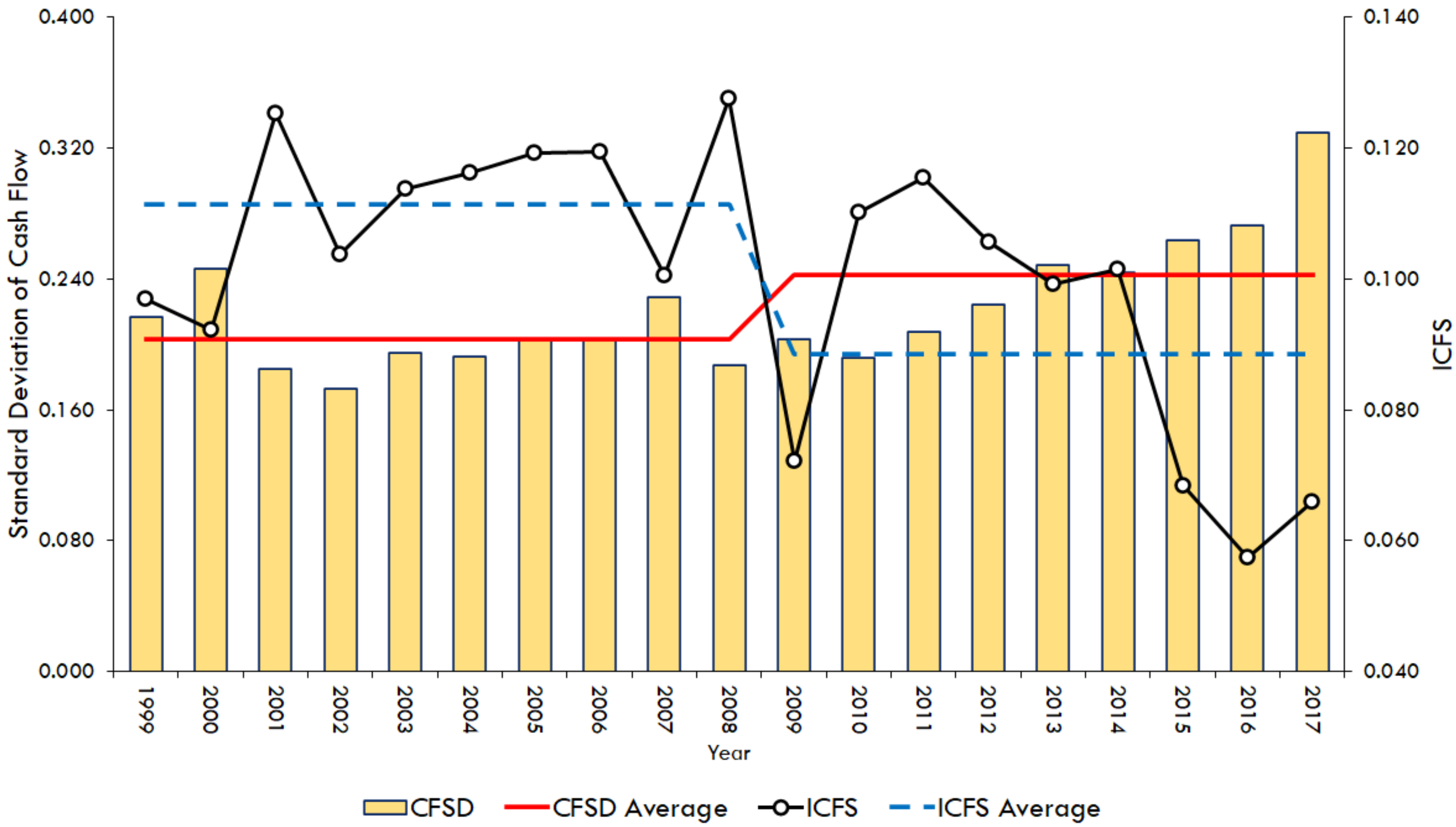

Figure 10: *ICFS* and Cash Flow Standard Deviation in the US: 1999 – 2017

The figure plots *ICFS* and cash flow standard deviation from 1999 to 2017. We estimate the cross-sectional regression of investment on Tobin's Q and cash flow for each year to get yearly *ICFS*. We also estimate the cross-sectional standard deviation of cash flow (CFSD) for each year to get yearly standard deviation. We then construct the time-series of *ICFS* and CFSD. Using the time-series, we calculate the average values of *ICFS* and CFSD for the pre- and post-GFC, respectively. *ICFS* Average (blue dash) and CFSD Average (red solid) plot the average values.

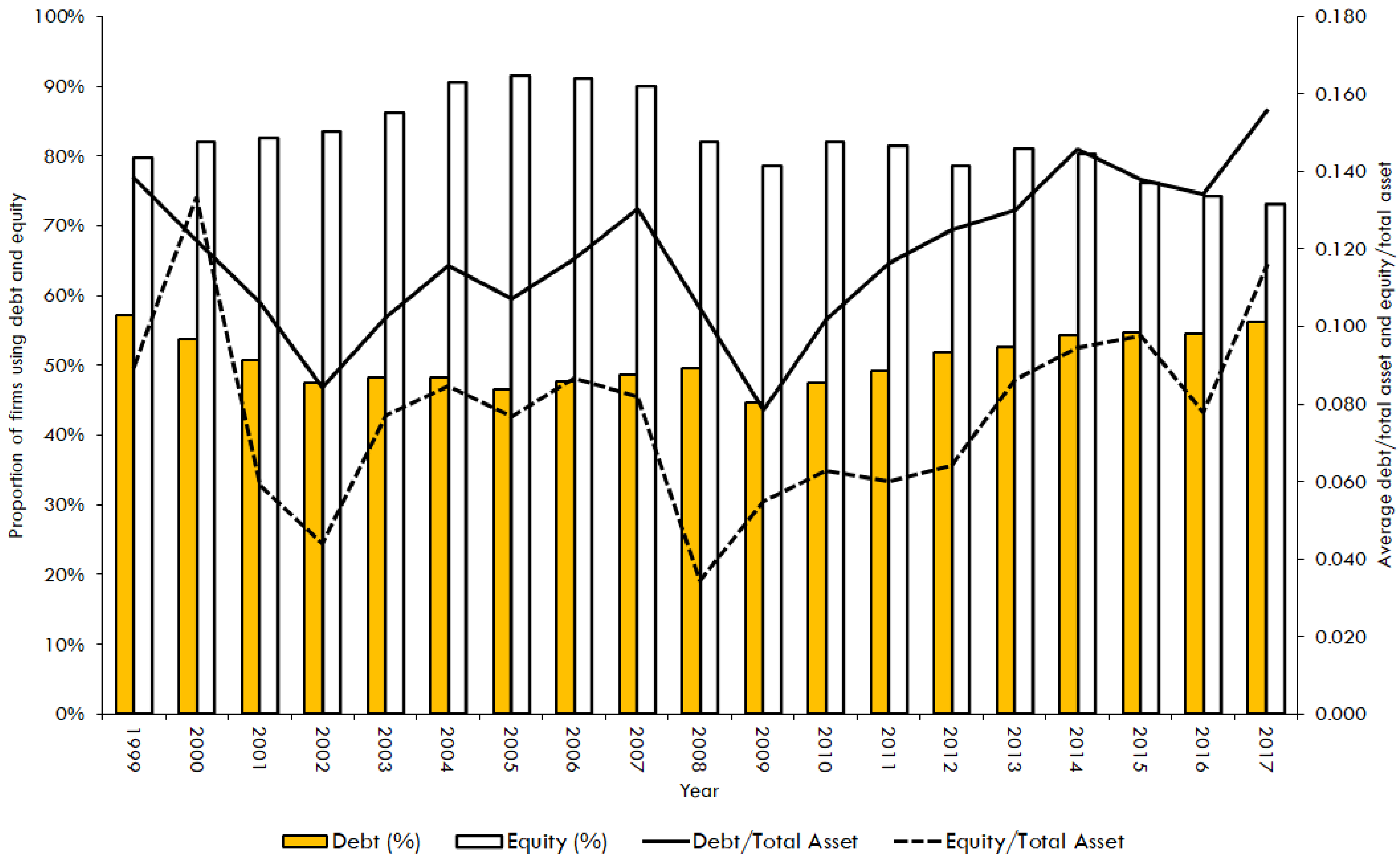

Figure 11: Debt and equity in the US: 1999 – 2017

The figure plots the proportion of firms using debt and equity issuance and the cross-sectional average ratio of debt to total asset and equity issuance to total asset in each year from 1999 to 2017. The year 1998 is missing because both debt and equity issuance are scaled by the lagged total asset.

Table 1: Summary Statistics

	China						US					
Variable	N	Mean	Median	SD	Min	Max	N	Mean	Median	SD	Min	Max
Investment (*INV*)	30,677	0.067	0.042	0.074	0.000	0.394	61,673	0.060	0.035	0.075	0.000	0.451
Cash Flow (*CF*)	30,677	0.051	0.048	0.093	−0.252	0.354	56,815	0.076	0.106	0.185	-0.772	0.472
Debt (*DEBT*)	30,677	0.251	0.203	0.237	0.000	1.153	61,673	0.118	0.000	0.255	0.000	1.548
Issue (*ISSUE*)	30,677	0.032	0.000	0.099	0.000	0.610	60,567	0.078	0.005	0.249	0.000	1.683
Cash Flow Volatility (*CFVOL*) (6-Year)	11,706	1.503	0.422	4.146	0.051	33.286	37,777	0.548	0.195	1.277	0.040	9.764
Cash Flow Volatility (*CFVOL*) (5-Year)	13,853	1.488	0.427	4.065	0.049	32.891	33,476	0.555	0.195	1.299	0.044	9.887
Cash Flow Volatility (*CFVOL*) (4-Year)	16,095	1.482	0.434	3.969	0.046	32.153	29,620	0.557	0.194	1.301	0.046	9.923
Cash Flow Volatility (*CFVOL*) (3-Year)	18,480	1.465	0.439	3.775	0.046	29.861	26,149	0.554	0.193	1.281	0.047	9.545
Q (*Q*)	30,677	2.099	1.534	1.916	0.201	11.693	61,424	1.801	1.274	1.630	0.296	10.987
EBITDA (*EBITDA*)	30,677	0.093	0.085	0.083	−0.184	0.415	61,673	0.076	0.116	0.225	-0.954	0.522
Intagible Assets (*INTAN*)	30,618	0.045	0.029	0.053	0.000	0.311	59,518	0.169	0.093	0.194	0.000	0.759
Fixed Assets (*FA*)	30,677	0.257	0.224	0.178	0.002	0.750	61,635	0.262	0.174	0.242	0.002	0.912
Size (*SIZE*)	30,677	21.744	21.600	1.262	19.074	25.563	61,673	6.161	6.052	2.073	2.042	11.291
Leverage (*LEV*)	30,677	0.469	0.468	0.217	0.051	1.133	61,637	0.211	0.164	0.046	0.958	0.000
Dividend (*DIV*)	30,677	0.000	0.000	0.002	0.000	0.014	61,157	0.013	0.000	0.051	0.000	0.161
Margin (*MARGIN*)	30,677	0.031	0.033	0.066	−0.302	0.190	61,673	0.033	0.374	2.441	−20.777	0.935
Return (*RET*)	30,306	0.230	0.003	0.730	−0.706	3.233	60,811	0.208	0.073	0.489	-0.791	3.916
R&D (*RD*)	12,641	0.025	0.020	0.022	0.000	0.123	61,673	0.063	0.005	0.122	0.000	0.695
WW (*WW*)	30,609	−0.944	−0.939	0.061	−1.128	−0.791	60,042	-0.298	-0.295	0.115	-0.565	-0.029

The table presents the summary statistics of variables used for our empirical analysis of China and US firms. This includes the number of observations (N), mean, median, standard deviation (SD), minimum value (Min), and maximum value (Max) for 1999 – 2017. The variables for Chinese firms are from CSMAR's 'Financial Statement' table except for R&D from the 'Enterprise Innovation' table and Return from the 'Stock Trading' table, and those for US firms are from COMPUSTAT and CRSP. Investment (*INV*) denotes capital expenditure. Cash Flow (*CF*) is the cash flow from operating activities. Debt (*DEBT*) is the proceeds of debt sales. Issue (*ISSUE*) is the proceeds from issuing shares. EBITDA (*EBITDA*) is the earnings before interest, tax, depreciation, and amortization. R&D (*RD*) is the R&D expenses. Dividend (*DIV*) is the ratio of total dividends. All the variables above are scaled by the lagged total assets. Cash flow volatility (*CFVOL*) (3-year, 4-year, 5-year, 6-year) is the standard deviation of the firm's quarterly operating cash flow over the past 12, 16, 20, 24 quarters and is scaled by the absolute value of cash flow. Q (*Q*) is the market to book ratio at the beginning of the year, which is the lagged market value over the lagged total asset. Intangible Assets (*INTAN*) is defined as the book value of total assets. Fixed Assets (*FA*) is the amount of fixed assets after deducting accumulated depreciation and impairment scaled by total assets. Size (*SIZE*) is the natural log of the total assets. Leverage (*LEV*) is defined as the total liability over the total assets. Dividend (*DIV*)is the dividend payout scaled by total assets. Net margin (*MARGIN*) is the net profits normalised by total assets at the beginning of the year. Return (*RET*) is the annual stock return with cash dividend reinvestment. WW (*WW*) is Whited-Wu index calculated following Whited and Wu (2006).

Table 2: Identifications of relationship between internal funds and external financing

Channel		Pecking Order			Adjust Cost			Liquidity		Credit Multiplier	
	SS(C)	SS(U)	SS(C*)	SS(U*)	SS(U)	SS(U*)	WS	WS(C)	WS(C*)	WC	SC
CF	−0.4660**	−1.0180***	−0.4850***	−0.9190***	−1.1940***	−1.2060***	−0.7340***	−0.5920***	−0.6560***	0.6040***	1.3690***
	(0.231)	(0.2060)	(0.1810)	(0.2230)	(0.0663)	(0.0740)	(0.0373)	(0.0524)	(0.0550)	(0.0626)	(0.1830)
INFASY	1.0080***	0.6060***	0.6890***	0.5200**							
	(0.1730)	(0.2090)	(0.1930)	(0.2260)							
INFASY ∗ *CF*	−7.161***	−1.298	−6.486***	−2.184							
	(2.3270)	(1.7510)	(1.9350)	(2.0210)							
ADJCOST					0.4030***	0.3950***					
					(0.0655)	(0.0667)					
ADJCOST ∗ *CF*					−1.5680***	−1.3210***					
					(0.4620)	(0.4590)					
LIQUID							−0.0660	−0.1180***	−0.1030**		
							(0.0477)	(0.0434)	(0.0469)		
LIQUID ∗ *CF*							0.1910	0.4060*	0.2760		
							(0.2240)	(0.2360)	(0.2760)		
TANGIBLE										−0.1310***	−0.1400*
										(0.0380)	(0.0797)
TANGIBLE ∗ *CF*										0.6190***	0.8010
										(0.2320)	(0.5220)
Hypothesis											
$H_0 : \beta_3 \geq 0$	0.001	0.230	0.001	0.141	0.000	0.002					
$H_0 : \beta_3 \leq 0$							0.197	0.043	0.159	0.004	0.063
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	288	731	321	653	1,594	1,422	9,475	3,992	4,144	5,344	1,503
R-squared	47%	41%	43%	41%	49%	49%	13%	12%	12%	14%	43%
Number of firms	79	130	89	121	211	204	760	539	611	464	177

Table reports the results of regression (12), (14), (17) and (18). We control firm, industry and year fixed effects in the regression. SS, WS, WC and SC represent strong substitutability, weak substitutability, weak complementarity, and strong complementarity. C/C* and U/U* denote financially constrained and unconstrained firms identified by firm size/WW index. The dependent variable is the proceeds of debt sales. *INFASY* denotes the variable of information asymmetry. We use the standard deviation of regression residuals from the extended FDD model in the equation (13) as a proxy for information asymmetry. *ADJCOST* denotes the variable of adjustment cost. We use the value of change in debt in the equation (15) – (16). *LIQUID* denotes the variable of liquid assets and we use the firm's cash holding scaled by the lagged total assets as a proxy. *TANGIBLE* denotes the variable of tangible assets and we use fixed assets as a proxy. Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively. To test the channels of pecking order theory and adjustment cost, we perform the one-tailed t-test of $H_0 : \beta \geq 0$. On the other hand, we perform the one-tailed t-test of $H_0 : \beta \leq 0$ to test the channels of liquidity and credit multiplier. We report a p-value for each test in this table.

Table 3: Cash Flow Uncertainty and Investment-Cash-Flow Sensitivity

	(1) 3-year		(2) 4-year		(3) 5-year		(4) 6-year	
Q	0.0077***	0.0074***	0.0079***	0.0077***	0.0078***	0.0077***	0.0081***	0.0080***
	(0.0005)	(0.0005)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0007)	(0.0007)
CF	0.0956***	0.1130***	0.0979***	0.1120***	0.0960***	0.1010***	0.0911***	0.0968***
	(0.0089)	(0.0109)	(0.0097)	(0.0115)	(0.0104)	(0.0107)	(0.0110)	(0.0112)
$CFVOL$	−0.0004***	−0.0003***	−0.0003**	−0.0003**	−0.0003***	−0.0003**	−0.0003**	−0.0002**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$CFVOL \cdot CF$		−0.0662***		−0.0528***		−0.0159***		−0.0157***
		(0.0180)		(0.0185)		(0.0056)		(0.0036)
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	18,480	18,480	16,095	16,095	13,853	13,853	11,706	11,706
R-squared	9%	9%	10%	10%	9%	10%	9%	10%
Number of firm	2,489	2,489	2,423	2,423	2,301	2,301	2,058	2,058

Table reports the results of regression (10) across four different estimation periods of cash flow volatility. We control firm, industry and year fixed effects in the regression. The dependent variable is investment scaled by the lagged total asset (*INV*). The independent variables are Tobin's Q (Q), cash flow (*CF*), the cash flow volatility (*CFVOL*), and the interaction between cash flow and cash flow volatility ($CF\dot{C}FVOL$). Tobin's Q is a lagged one, cash flow is scaled by the lagged total asset and cash flow volatility scaled by the absolute value of cash flow. See Appendix A for the variable definitions. Note that we also estimate the model without the interacting term, $CFVOL \cdot CF$ to identify the impact of cash flow uncertainty on investment through *ICFS* channel. Column (1), (2), (3), and (4) measure cash flow volatility by using 12, 16, 20, 24 quarters of cash flow, respectively. Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively.

Table 4: Test of Hypothesis: Baseline Model

	SS	WS	WC	SC
Q	0.0079***	0.0075***	0.0070***	0.0047**
	(0.0016)	(0.0010)	(0.0012)	(0.0020)
CF	−0.0130	0.0228*	0.2820***	0.5130***
	(0.0362)	(0.0130)	(0.0298)	(0.0659)
$CFVOL$	−0.0004	−0.0004**	0.0003	-0.0004
	(0.0002)	(0.0002)	(0.0003)	(0.0008)
$CFVOL{\cdot}CF$	−0.0974	−0.0428*	−0.0976*	−0.4150***
	(0.0689)	(0.0221)	(0.0509)	(0.1120)
Hypothesis 1				
$H_0 : ICFS = 0$	0.720			
$H_0 : ICFS_\sigma = 0$	0.159			
Hypothesis 2 and 3				
$H_0 : ICFS \leq 0$		0.040	0.000	0.000
$H_0 : ICFS_\sigma \geq 0$		0.027	0.028	0.000
Firm	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	1,702	5,916	3,302	858
R-squared	10%	8%	18%	36%
Number of firm	290	744	447	149

Table reports the results of regression (10) across four different testing groups. We control firm, industry and year fixed effects in the regression. SS, WS, WC and SC represent strong substitutability, weak substitutability, weak complementarity, and strong complementarity. The independent variables are Tobin's Q, cash flow, cash flow volatility, and the interaction between cash flow and cash flow volatility. Firm, industry, and year fixed effects are controlled. Cash flow volatility is measured with the standard deviation of cash flow over the past 12 quarters. Standard errors are clustered by firm and time. Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively. To test Hypothesis 1, we estimate the model for the SS group and perform the two-tailed t-test for for $H_0 : ICFS\ (\beta_2) = 0$ and $H_0 : ICFS_\sigma\ (\beta_4) = 0$, respectively. Unlike the test of Hypothesis 1, we need a one-tailed t-test for Hypothesis 2 and 3, because we are interested in testing $ICFS > 0$ and $ICFS_\sigma < 0$. To this end, we estimate the empirical model for WS, WC, and SC respectively, and perform the one-tailed t-test of $H_0 : ICFS \leq 0$ and $H_0 : ICFS_\sigma \geq 0$ for each group. We report a p-value for each test in this table.

Table 5: Test of Hypothesis: Extended Model

	SS	WS	WC	SC
Q	0.0044**	0.0038***	0.0038***	0.0056***
	(0.0018)	(0.0012)	(0.0013)	(0.0019)
CF	−0.0154	0.0296**	0.2880***	0.5520***
	(0.0347)	(0.0126)	(0.0303)	(0.0649)
CFVOL	−0.0002	−0.0004**	0.0002	0.0001
	(0.0002)	(0.0002)	(0.0003)	(0.0008)
CFVOL·CF	−0.0780	−0.0590***	−0.0971**	−0.4290***
	(0.0714)	(0.0220)	(0.0478)	(0.1130)
RET	0.0229**	0.00174	−0.0137	−0.0339*
	(0.0109)	(0.00594)	(0.0122)	(0.0176)
CASH	0.0489**	0.0120	0.0438**	0.0962***
	(0.0216)	(0.0140)	(0.0211)	(0.0365)
LEV	0.00139	−0.0232**	−0.0220	−0.0346
	(0.0204)	(0.0103)	(0.0137)	(0.0352)
FA	−0.102***	−0.0826***	−0.0846***	−0.0682*
	(0.0291)	(0.0161)	(0.0188)	(0.0372)
MARGIN	0.148***	0.104***	0.116***	0.0564
	(0.0478)	(0.0216)	(0.0308)	(0.0573)
SIZE	−0.0152**	−0.0106***	−0.0113***	0.00862
	(0.00609)	(0.00324)	(0.00353)	(0.00668)
Hypothesis 1				
$H_0 : ICFS = 0$	0.657			
$H_0 : ICFS_\sigma = 0$	0.276			
Hypothesis 2 and 3				
$H_0 : ICFS \leq 0$		0.010	0.000	0.000
$H_0 : ICFS_\sigma \geq 0$		0.004	0.021	0.000
Firm	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	1,702	5,916	3,302	858
R-squared	15%	12%	22%	39%
Number of firms	290	744	447	149

Table reports the results of regression (11) across four testing groups. We control firm, industry and year fixed effects in the regression. SS, WS, WC and SC represent strong substitutability, weak substitutability, weak complementarity, and strong complementarity, respectively. The independent variables are Tobin's Q, cash flow, cash flow volatility, the interaction between cash flow and cash flow volatility, and control variables. We mainly follow Lian and Ma (2021) for constructing control variables: Stock returns (*RET*), cash holdings (*CASH*), book leverage (*LEV*), fixed assets (*FA*), margin (*MARGIN*), and size (*SIZE*) at the end of $t-1$. Note that cash holdings, book leverage, fixed assets, and margin are scaled by the current total assets. Standard errors are clustered by firm and time. Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively. To test Hypothesis 1, we estimate the model for the SS group and perform the two-tailed t-test for for $H_0 : ICFS\ (\beta_2) = 0$ and $H_0 : ICFS_\sigma\ (\beta_4) = 0$, respectively. Unlike the test of Hypothesis 1, we need a one-tailed t-test for Hypothesis 2 and 3, because we are interested in testing $ICFS > 0$ and $ICFS_\sigma < 0$. To this end, we estimate the empirical model for WS, WC, and SC respectively, and perform the one-tailed t-test of $H_0 : ICFS \leq 0$ and $H_0 : ICFS_\sigma \geq 0$ for each group. We report a p-value for each test in this table.

Table 6: Exogenous Cash Flow Uncertainty Shock on *ICFS*: Single Structural Change

	SS	WS	WC	SC
CF	0.0964	0.0467	0.376***	0.729***
	(0.102)	(0.0474)	(0.116)	(0.231)
$CF * D_{Post}$	-0.0814	-0.0225	-0.182	-0.288
	(0.103)	(0.0128)	(0.128)	(0.177)
Hypothesis 1				
$H_0 : ICFS = 0$	0.243			
$H_0 : \Delta ICFS = 0$	0.198			
Hypothesis 2 and 3				
$H_0 : ICFS \leq 0$		0.000	0.000	0.000
$H_0 : \Delta ICFS \geq 0$		0.046	0.054	0.052
Control	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	395	1,176	579	214
R-squared	0.191	0.103	0.250	0.416
Number of firms	70	168	94	40

Table reports the results of regression (19) across four testing groups. The GFC is likely to affect both cash flow uncertainty and the relationship between internal funds and external funds. To control this problem, we select only firms whose relationships remain unchanged after the GFC. We control firm, industry and year fixed effects in the regression. SS, WS, WC and SC represent strong substitutability, weak substitutability, weak complementarity, and strong complementarity. The independent variables are Tobin's Q and cash flow, and control variables (see Table 5). D_{Post} is a dummy variable taking a value of 1 for $Year > 2008$ and 0 otherwise. Standard errors are clustered by firm and year. Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively. A coefficient on *CF* is interpreted as *ICFS* for the pre-GFC and that on $CF \cdot D_{Post}$ as the change of *ICFS* after GFC, i.e. $\Delta ICFS$, respectively. To test Hypothesis 1, we estimate the model for the SS group and perform the two-tailed t-test for $H_0 : ICFS = 0$ and $H_0 : \Delta ICFS = 0$. Unlike the test of Hypothesis 1, we need a one-tailed t-test for Hypothesis 2 and 3, because we are interested in testing $ICFS > 0$ and $\Delta ICFS < 0$. To this end, we estimate the model for WS, WC, and SC, respectively, and perform the one-tailed t-test of $H_0 : ICFS \leq 0$ and $H_0 : \Delta ICFS \geq 0$ for each group. We report a p-value for each test in this table.

Table 7: Exogenous Cash Flow Uncertainty Shock on *ICFS*: Difference-in-Difference Specification

	SS	WS	WC	SC
CF	0.1030	0.0461*	0.1890**	0.7710***
	(0.118)	(0.0262)	(0.0949)	(0.297)
$CF \cdot D_{Post}$	-0.0996	-0.1480*	-0.2607**	-0.4000*
	(0.122)	(0.0902)	(0.109)	(0.2105)
$CF \cdot D_{SOE}$	-0.0045	0.0084	0.377**	-0.1709
	(0.148)	(0.102)	(0.171)	(0.115)
$CF \cdot D_{Post} \cdot D_{SOE}$	0.0411	0.0524	0.3262	0.6703
	(0.179)	(0.108)	(0.209)	(0.458)
$CF + CF \cdot D_{SOE}$	0.0985	0.0545**	0.5660***	0.6001*
	(0.0981)	(0.0252)	(0.0606)	(0.3304)
$CF \cdot D_{Post} + CF \cdot D_{Post} \cdot D_{SOE}$	−0.0585	−0.0956	0.0655	0.2703
	(0.0491)	(0.1088)	(0.0641)	(0.5022)
Hypothesis 1				
$H_0 : ICFS_{non-SOEs} = 0$	0.383			
$H_0 : \Delta ICFS_{non-SOEs} = 0$	0.414			
$H_0 : ICFS_{SOEs} = 0$	0.312			
$H_0 : \Delta ICFS_{SOEs} = 0$	0.233			
Hypothesis 2 and 3				
$H_0 : ICFS_{non-SOEs} \leq 0$		0.039	0.023	0.000
$H_0 : \Delta ICFS_{non-SOEs} \geq 0$		0.050	0.017	0.028
$H_0 : ICFS_{SOEs} \leq 0$		0.015	0.000	0.035
$H_0 : \Delta ICFS_{SOEs} \geq 0$		0.189	0.862	0.701
Control	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	395	1,176	579	214
R-squared	0.205	0.105	0.294	0.455
Number of firms	70	168	94	40

Table reports the results of regression (20) across four testing groups. The GFC is likely to affect both cash flow uncertainty and the relationship between internal funds and external funds. To control this problem, we select only firms whose relationships remain unchanged after the GFC. We control firm, industry and year fixed effects in the regression. SS, WS, WC and SC represent strong substitutability, weak substitutability, weak complementarity, and strong complementarity. The independent variables are Tobin's Q and cash flow, and control variables (see Table 5). D_{Post} is a dummy variable taking a value of 1 for $Year > 2008$ and 0 otherwise. D_{SOE} is a dummy variable taking a value of 1 for SOEs and 0 for non-SOEs. Standard errors are clustered by firm and year. Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively. A coefficient on CF is interpreted as $ICFS$ for non-SOEs during the pre-GFC, i.e. $ICFS_{non-SOEs}$, and that on $CF \cdot D_{Post}$ as the change of $ICFS$ after GFC for non-SOEs, i.e. $\Delta ICFS_{non-SOEs}$, respectively. The summation of coefficients on CF and $CF \cdot D_{SOE}$ is interpreted as $ICFS$ for SOEs during the pre-GFC, i.e. $ICFS_{SOEs}$, and the summation of coefficients on $CF \cdot D_{Post}$ and $CF \cdot D_{SOE}$ as the change of $ICFS$ after GFC for SOEs, i.e. $\Delta ICFS_{SOEs}$, respectively. To test Hypothesis 1, we estimate the model for the SS group and perform the two-tailed t-test for $H_0 : ICFS_{non-SOEs} = 0$ and $H_0 : \Delta ICFS_{non-SOEs} = 0$, and $H_0 : ICFS_{SOEs} = 0$ and $H_0 : \Delta ICFS_{SOEs} = 0$. Unlike the test of Hypothesis 1, we need a one-tailed t-test for Hypothesis 2 and 3, because we are interested in testing $ICFS > 0$ and $\Delta ICFS < 0$. To this end, we estimate the model for WS, WC, and SC respectively, and perform the one-tailed t-test of $H_0 : ICFS_{non-SOEs} \leq 0$ and $H_0 : \Delta ICFS_{non-SOEs} \geq 0$, and $H_0 : ICFS_{SOEs} \leq 0$ and $H_0 : \Delta ICFS_{SOEs} \geq 0$ for each group. We report a p-value for each test in this table.

Table 8: Test of Hypothesis: Downside Cash Flow Volatility

	SS	WS	WC	SC
Q	0.0043**	0.0038***	0.0038***	0.0056***
	(0.0018)	(0.0012)	(0.0013)	(0.0019)
CF	−0.0176	0.0302**	0.2860***	0.5510***
	(0.0344)	(0.0128)	(0.0298)	(0.0641)
$DCFVOL$	−0.0004	−0.0006**	0.0002	0.0000
	(0.0004)	(0.0003)	(0.0005)	(0.0012)
$DCFVOL{\cdot}CF$	−0.1030	−0.0932***	−0.1370**	−0.6790***
	(0.1030)	(0.0356)	(0.0678)	(0.1800)
Hypothesis 1				
$H_0 : ICFS = 0$	0.610			
$H_0 : ICFS_\sigma = 0$	0.318			
Hypothesis 2 and 3				
$H_0 : ICFS \leq 0$		0.009	0.000	0.000
$H_0 : ICFS_\sigma \geq 0$		0.005	0.022	0.000
Control	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes
Indudstry	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Observations	1,702	5,916	3,302	858
R-squared	15%	12%	22%	39%
Number of firms	290	744	447	149

Table reports the results of regression (11) across four testing groups. We control firm, industry and year fixed effects in the regression. SS, WS, WC and SC represent strong substitutability, weak substitutability, weak complementarity, and strong complementarity. The independent variables are Tobin's Q (Q), cash flow (CF), downside cash flow volatility ($DCFVOL$), the interaction between cash flow and stock return volatility ($DCFVOL*CF$), and control variables (see Table 5. We measure downside cash flow volatility ($DCFVOL$) by the equation (9) using the past 12 quarters. Standard errors are clustered by firm and time. Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively. To test Hypothesis 1, we estimate the model for the SS group and perform the two-tailed t-test for for $H_0 : ICFS\ (\beta_2) = 0$ and $H_0 : ICFS_\sigma\ (\beta_4) = 0$, respectively. Unlike the test of Hypothesis 1, we need a one-tailed t-test for Hypothesis 2 and 3, because we are interested in testing $ICFS > 0$ and $ICFS_\sigma < 0$. To this end, we estimate the empirical model for WS, WC, and SC respectively, and perform the one-tailed t-test of $H_0 : ICFS \leq 0$ and $H_0 : ICFS_\sigma \geq 0$ for each group. We report a p-value for each test in this table.

Table 9: Test of Hypothesis: Return-based Uncertainty Measures

	SS			WS			WC			SC		
	TOTVOL	*SYSVOL*	*FIRMVOL*	*TOTVOL*	*SYSVOL*	*FIRMVOL*	*TOTVOL*	*SYSVOL*	*FIRMVOL*	*TOTVOL*	*SYSVOL*	*FIRMVOL*
Q	0.0041**	0.0039**	0.0041**	0.0047***	0.0046***	0.0046***	0.0040***	0.0042***	0.0037***	0.0048**	0.0051**	0.0050**
	(0.0016)	(0.0016)	(0.0016)	(0.0012)	(0.0011)	(0.0012)	(0.0013)	(0.0013)	(0.0013)	(0.0021)	(0.0020)	(0.0022)
CF	−0.0194	−0.0432	0.00943	0.1010***	0.0670**	0.0959***	0.3120***	0.3720***	0.2110***	0.2090	0.1680	0.3660***
	(0.0735)	(0.0647)	(0.0665)	(0.0313)	(0.0266)	(0.0290)	(0.0715)	(0.0610)	(0.0658)	(0.1380)	(0.1270)	(0.1290)
RETVOL	−0.0469	−0.0149	−0.0480	0.0121	0.0126	0.0277	0.0498	−0.0251	0.0984	−0.1080	−0.1920	−0.0656
	(0.0531)	(0.0625)	(0.0589)	(0.0348)	(0.0415)	(0.0360)	(0.0526)	(0.0565)	(0.0616)	(0.0976)	(0.1230)	(0.1000)
RETVOL·CF	0.0239	0.2480	−0.2540	−0.4950**	−0.3570	−0.6930**	−0.3030	−0.9830*	0.5560	1.7380*	2.7690**	1.0200
	(0.4200)	(0.5010)	(0.5540)	(0.2010)	(0.2200)	(0.2870)	(0.4560)	(0.5010)	(0.6620)	(0.8820)	(1.1470)	(1.1680)
Hypothesis 1												
$H_0 : ICFS = 0$	0.792	0.504	0.887									
$H_0 : ICFS_\sigma = 0$	0.955	0.622	0.647									
Hypothesis 2 and 3												
$H_0 : ICFS \leq 0$				0.001	0.006	0.000	0.000	0.000	0.001	0.066	0.095	0.002
$H_0 : ICFS_\sigma \geq 0$				0.007	0.052	0.008	0.254	0.025	0.800	0.975	0.992	0.808
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,988	1,984	1,984	6,940	6,931	6,931	3,815	3,809	3,809	1,017	1,013	1,013
R-squared	15%	15%	15%	13%	13%	13%	19%	20%	20%	37%	37%	36%
Number of firms	306	306	306	750	750	750	452	452	452	167	167	167

Table reports the results of regression (11) across four testing groups. We control firm, industry and year fixed effects in the regression. SS, WS, WC and SC represent strong substitutability, weak substitutability, weak complementarity, and strong complementarity. The independent variables are Tobin's Q (Q), cash flow (CF), stock return volatility ($RETVOL$), and the interaction between cash flow and stock return volatility ($RETVOL * CF$). The stock return volatility is measured in three ways: First, total volatility ($TOTVOL$) is measured by the firm-specific constant-mean-return model which is the same model used for the cash flow volatility. Note that we use monthly stock returns. Second, we decompose $TOTVOL$ into the systematic part ($SYSVOL$) and the firm-specific part ($FIRMVI$) based on Fama and French (1993) three-factor model. Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively. To test Hypothesis 1, we estimate the model for the SS group and perform the two-tailed t-test for for $H_0 : ICFS(\beta_2) = 0$ and $H_0 : ICFS_\sigma(\beta_4) = 0$, respectively. Unlike the test of Hypothesis 1, we need a one-tailed t-test for Hypothesis 2 and 3, because we are interested in testing $ICFS > 0$ and $ICFS_\sigma < 0$. To this end, we estimate the empirical model for WS, WC, and SC respectively, and perform the one-tailed t-test of $H_0 : ICFS \leq 0$ and $H_0 : ICFS_\sigma \geq 0$ for each group. We report a p-value for each test in this table.

Table 10: Measurement Error in Q

	LL				EW				Sales Growth			
	SS	WS	WC	SC	SS	WS	WC	SC	SS	WS	WC	SC
Q	0.0096**	0.0134***	0.0138**	0.0169*	−0.0164	−0.0053	−0.0147**	−0.0102	0.0077*	0.0037*	0.0073*	0.0059
	(0.0045)	(0.0035)	(0.0059)	(0.0086)	(0.0174)	(0.0048)	(0.0059)	(0.0099)	(0.0042)	(0.0019)	(0.0038)	(0.0057)
CF	−0.0013	0.0389***	0.3180***	0.6120***	0.0153	0.0705***	0.3390***	0.5480***	−0.0018	0.0337***	0.2920***	0.5510***
	(0.0399)	(0.0130)	(0.0356)	(0.0732)	(0.0354)	(0.0171)	(0.0357)	(0.0846)	(0.0358)	(0.0130)	(0.0321)	(0.0660)
CFVOL	0.0000	−0.0003	0.0002	−0.0002	−0.0009**	−0.0005***	0.0000	0.0005	−0.0001	−0.0003*	0.0003	0.0003
	(0.0002)	(0.0002)	(0.0004)	(0.0008)	(0.0004)	(0.0002)	(0.0004)	(0.0007)	(0.0002)	(0.0002)	(0.0003)	(0.0008)
CF·CFVOL	−0.0587	−0.0681***	−0.0940**	−0.5380***	−0.1150*	−0.0828**	−0.1530**	−0.3660***	−0.0864	−0.0639**	−0.1010**	−0.4260***
	(0.0701)	(0.0243)	(0.0476)	(0.1160)	(0.0632)	(0.0337)	(0.0754)	(0.1040)	(0.0734)	(0.0250)	(0.0502)	(0.1140)
Hypothesis 1												
$H_0 : ICFS = 0$	0.973				0.666				0.960			
$H_0 : ICFS_\sigma = 0$	0.403				0.069				0.240			
Hypothesis 2 and 3												
$H_0 : ICFS \leq 0$		0.001	0.000	0.000		0.000	0.000	0.000		0.005	0.000	0.000
$H_0 : ICFS_\sigma \geq 0$		0.003	0.024	0.000		0.007	0.021	0.000		0.005	0.023	0.000
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes					Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes					Yes	Yes	Yes	Yes
Observations	1,318	5,130	2,730	654	1702	5,916	3,302	858	1,638	5,767	3,190	816
R-squared	15%	14%	22%	44%	10%	12%	16%	26%	14%	12%	20%	39%
Number of firms	248	698	412	122	290	744	447	149	279	740	443	145

Table reports the results of regression (11) using alternative IVs and proxy for Q to avoid measurement error in Q across four different testing groups. We control firm, industry and year fixed effects in the regression. SS, WS, WC and SC represent strong substitutability, weak substitutability, weak complementarity, and strong complementarity, respectively. The independent variables are Tobin's Q, cash flow, cash flow volatility, the interaction between cash flow and cash flow volatility, and control variables (see Table 5). Panel LL reports the results where the fitted MB replaces MB as in Lewellen and Lewellen (2016). Panel EW reports GMM results with higher-order moments as IVs (Erickson and Whited, 2000, 2012). The last panel report the result where we use sales growth as the alternative proxy for Q. Standard errors are clustered by firm and time. Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively. To test Hypothesis 1, we estimate the model for the SS group and perform the two-tailed t-test for for $H_0 : ICFS\ (\beta_2) = 0$ and $H_0 : ICFS_\sigma\ (\beta_4) = 0$, respectively. Unlike the test of Hypothesis 1, we need a one-tailed t-test for Hypothesis 2 and 3, because we are interested in testing $ICFS > 0$ and $ICFS_\sigma < 0$. To this end, we estimate the empirical model for WS, WC, and SC respectively, and perform the one-tailed t-test of $H_0 : ICFS \leq 0$ and $H_0 : ICFS_\sigma \geq 0$ for each group. We report a p-value for each test in this table.

Table 11: Test of Hypothesis: Extended Model with US data

	Debt				Equity				Debt and Equity			
	SS	WS	WC	SC	SS	WS	WC	SC	SS	WS	WC	SC
Q	0.0099***	0.0056***	0.0066***	0.0095***	0.0033***	0.0055***	0.0069***	0.0043***	0.0047***	0.0055***	0.0055***	0.0076***
	(0.0018)	(0.0008)	(0.0010)	(0.0023)	(0.0010)	(0.0008)	(0.0011)	(0.0010)	(0.0011)	(0.0007)	(0.0010)	(0.0017)
CF	−0.0145	0.0129	0.1122***	0.1757***	−0.0102	0.0339***	0.0892***	0.1189***	−0.0124	0.0212***	0.1305***	0.1709***
	(0.0142)	(0.0084)	(0.0153)	(0.0322)	(0.0098)	(0.0088)	(0.0124)	(0.0192)	(0.0097)	(0.0062)	(0.0164)	(0.0248)
CFVOL	−0.0002	−0.0005	−0.0002	0.0007	−0.0004	−0.0004	0.0002	0.0012	−0.0005	−0.0005	0.0005	0.0018**
	(0.0009)	(0.0004)	(0.0005)	(0.0010)	(0.0005)	(0.0003)	(0.0003)	(0.0008)	(0.0005)	(0.0003)	(0.0004)	(0.0008)
CFVOL·CF	0.0256	−0.0216	−0.0773*	−0.1385***	0.0193	−0.0391**	−0.0651***	−0.0930***	0.0304*	−0.0243*	−0.0830	−0.1130***
	(0.0276)	(0.0157)	(0.0464)	(0.0530)	(0.0173)	(0.0186)	(0.0227)	(0.0277)	(0.0165)	(0.0144)	(0.0562)	(0.0374)
Hypothesis 1												
$H_0 : ICFS = 0$	0.309				0.296				0.202			
$H_0 : ICFS_\sigma = 0$	0.355				0.265				0.066			
Hypothesis 2 and 3												
$H_0 : ICFS \leq 0$		0.062	0.000	0.000		0.000	0.000	0.000		0.000	0.000	0.000
$H_0 : ICFS_\sigma \geq 0$		0.084	0.048	0.005		0.018	0.002	0.000		0.046	0.070	0.001
Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,754	7,663	8,012	2,638	2,615	6,303	10,077	3,845	2,969	7,794	9,029	3,481
R-squared	17%	10%	15%	21%	8%	11%	15%	16%	12%	10%	17%	20%
Number of firms	343	804	808	409	519	755	1,003	607	580	880	948	591

Table reports the results of regression (11) across four different testing groups using US firm-year data for 1999 – 2017. We control firm and year fixed effects in the regression. SS, WS, WC and SC represent strong substitutability, weak substitutability, weak complementarity, and strong complementarity, respectively. The independent variables are Tobin's Q, cash flow, cash flow volatility, the interaction between cash flow and cash flow volatility, and control variables (see Table 5). Robust standard errors are presented in parentheses. Note that *, **, and *** indicate the significance level at 10%, 5%, and 1%, respectively. To test Hypothesis 1, we estimate the model for the SS group and perform the two-tailed t-test for for $H_0 : ICFS\ (\beta_2) = 0$ and $H_0 : ICFS_\sigma\ (\beta_4) = 0$, respectively. Unlike the test of Hypothesis 1, we need a one-tailed t-test for Hypothesis 2 and 3, because we are interested in testing $ICFS > 0$ and $ICFS_\sigma < 0$. To this end, we estimate the empirical model for WS, WC, and SC respectively, and perform the one-tailed t-test of $H_0 : ICFS \leq 0$ and $H_0 : ICFS_\sigma \geq 0$ for each group. We report a p-value for each test in this table.

Appendix A Definitions of key variables

Assets (K): Total assets (CSMAR) A001000000 (COMPUSTAT) AT

Cash ($CASH$): Cash and cash equivalents (CSMAR) A001101000 (COMPUSTAT) CHE

Cash flow (CF): Cash received from sales of goods or rendering of services (CSMAR) C001000000 (COMPUSTAT) OANCF

Cash flow volatility ($CFVOL$): Standard deviation of firm's quarterly operating cash flow over the past 12 quarters (3 years).

Debt ($DEBT$): Proceeds of debt sales which are the proceeds from issuing bonds plus proceeds from borrowings (CSMAR) C003003000 + C003002000 (COMPUSTAT) DLTIS

EBITDA ($EBITDA$): Earings before interest, tax, depreciation and amortization (CSMAR) F050801B (COMPUSTAT) OIBDP

Equity issuance ($ISSUE$): Proceeds from issuing shares which are the cash received from the issuance of stocks by an enterprise (CSMAR) C003001000 (COMPUSTAT) SSTK

Firm size ($SIZE$): Natural logarithm of total assets

Investment (INV): Capital expenditure (CSMAR) C002006000 (COMPUSTAT) CAPX

Intangible assets ($INTAN$): Book value of intangible assets (CSMAR) A001218000 (COMPUSTAT) INTAN

Leverage (LEV): Total liabilities divided by total assets (CSMAR) A002000000/A001000000 (COMPUSTAT) (DLC+DLTT)/AT

Net fixed assets (FA): The net amount of fixed assets after deducting accumulated depreciation and impairment (CSMAR) A001212000 (COMPUSTAT) PPENT

Net margin ($MARGIN$): Net profits (sales minus cost of sales) scaled by sales (CSMAR) F050201B (COMPUSTAT) (SALE-COGS)/SALE

Tobin's Q (Q): Market value divided by total assets at the beginning of the year (CSMAR) F100901A (COMPUSTAT) (PRCC_F*CSHO+DLC+DLTT)/AT

Return (RET): Annual return with cash dividend reinvested (CSMAR) Yretwd (CRSP) Return

Sales ($SALES$): Cash Received From Sales Of Goods Or Rendering Of Services (CSMAR) C001001000 (COMPUSTAT) SALE

Dividend payout ratio (DIV): Cash dividend divided by total assets at the beginning of the year (CSMAR) NUMDIV (COMPUSTAT) DV

Current accrual (CA): Δcurrent assets – Δcurrent liabilities – Δcash + Δdebt in current liabilities (CSMAR) F082101B + D000103000

Interest expenses (IE): Expenses incurred to raise necessary funds for production (CSMAR) B001211000

Net financing (NF): Net cash flow from financing activities (CSMAR) C003000000

Dividend payout dummy ($DIVPOS$): A dummy variable that equals one if the firm pays cash dividends.

R&D (RD): R&D expenses (Not available until 2007 for CSMAR) (COMPUSTAT) RDSPENDSUM

Sales Growth (SG): The first difference of the logarithm of real sales.

Industry sales growth (ISG): The average industry sales growth of 3-digit industry code

Information asymmetry ($INFASY$): Measured with accruals quality following the spirit of Lee and Masulis (2009) and extend their FDD model by controlling both industry and year effects in a single panel regression framework.

Adjustment cost ($ADJCOST$): Adjustment cost of capital structure. Measured by estimating the value of change in debt in regression (15).

Liquidity ($LIQUID$): Cash and cash equivalents scaled by lagged total assets.

Tangible assets ($TANGIBLE$): Fixed assets scaled by total assets

WW index (WW): The variable measures financial constraints. The calculations follow Whited and Wu (2006)

Net assets (NA): Total assets minus cash and cash equivalents

Post GFC dummy (D_{Post}): A dummy variable that equals one if the year is greater than 2008

SOE dummy (D_{SOE}): A dummy variable that equals one if the firm's ultimate controllers are the central government, local governments or other SOEs.

Downside risk ($DCFVOL$): Downside cash flow volatility computed with negative cash flow shocks using the equation (9) over the past 12 quarters.

Stock return volatility ($TOTVOL$): The standard deviation of the stock return over the past 36 months (3 years).

Systematic stock return volatility ($SYSVOL$) : The systematic part of the stock return volatility, which is the volatility of the estimated factor loadings using Fama-French three-factor model over the past 36 months (3 years).

Firm-specific stock return volatility ($FIRMVOL$) : The firm-specific part of the stock return volatility. It is the volatility of the regression residuals of the Fama-French three-factor model over the past 36 months (3 years).