DOI 10.7603/s40570-016-0011-8

Volume 18, Number 4 – December 2016
China Accounting and Finance Review
中国会计与财务研究
2016年12月 第18卷 第4期

Corporate Pyramids and Stock Price Crash Risk: Evidence from China*

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Received 30th of August 2015 Accepted 7th of January 2016

Abstract

This paper examines the impact of corporate pyramids on the stock price crash risk of listed firms in China. Our results show that, first, the pyramidal layer of state-owned enterprises (SOEs) can reduce stock price crash risk through the three channels of improving financial statement transparency, increasing accounting conservatism, and decreasing overinvestment. Second, the greater the related party transactions, the weaker the negative relation between the pyramidal layer and crash risk, while this negative relation is strengthened by Hong Kong cross-listing. Further analysis shows that the corporate pyramidal layer of SOEs can also decrease stock price synchronicity. For non-state-owned enterprises (NSOEs), we find that there is an inverse U-shaped relationship between the corporate pyramidal layer, crash risk, and stock price synchronicity. These findings have important policy implications in promoting the sound and stable development of the capital market in China.

Keywords: Corporate Pyramids, Stock Price Crash Risk, Controlling Shareholders, Stock Price Synchronicity

CLC codes: F276.6, F830.91

* We thank Qing Yang and Chao Chen for their helpful suggestions at the 2014 CICF and the 2015 Joint CAFR/JAAF conferences. This study is supported by the National Natural Science Foundation of China (Project Nos. 71622010 and 71503283), the Outstanding Youth Talent Support Program of the Organization Department of the CPC Central Committee, the Fok Ying Tung Education Foundation (Grant No. 141080), the Humanities and Social Science Research Project of the Ministry of Education in China (Project No. 14YJC630069), the Social Science Research Project of Beijing (Project No. 15JGC173), the Program for Innovation Research in the Central University of Finance and Economics, Young Elite Teacher Project of Central University of Finance and Economics, and the Zhongcai-Pengyuan Local Finance Investment and Funding Research Institute. We would like to thank the editors and two anonymous reviewers for their helpful comments. All errors are our own.

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中国上市公司金字塔控股结构与股价崩盘风险

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摘要

本文考察中国上市公司金字塔控股结构对股价崩盘风险的影响。研究发现：（1）国有企业的金字塔层级能通过改善财务报告透明度、提高会计稳健性和降低过度投资三条路径降低股价崩盘风险；（2）在国有企业中，关联交易越多，金字塔层级与股价崩盘风险的负相关关系越弱，而香港上市有助于增强两者之间的负向关系。进一步的研究发现，国有企业金字塔层级的增加同样降低了股价同步性。在非国有企业中，金字塔层级与股价崩盘风险、股价同步性均呈倒“U”型关系。本文的研究对促进资本市场健康稳定发展具有重要的政策启示。

关键词：金字塔结构、股价崩盘风险、控股股东、股价同步性
中图分类号：F276.6、F830.91

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I. Introduction

Recently, stock price crash risk has attracted widespread attention from regulators, investors, and academics as it will harm not only individual investors' wealth but also the stability of the stock market and financial system. Although the current financial system in China is generally stable, the possibility of downward economic pressure is still high and financial fragility continues to increase (China Financial Stability Report, 2012). Thus, investigating the determinants of crash risk and mitigating such a risk will be helpful to the stable development of Chinese stock markets.

This paper investigates two basic questions: whether the pyramidal layer of listed firms affects crash risk in China and whether the nature of the controlling shareholder affects the relationship between the corporate pyramidal layer and crash risk. This investigation is based on several considerations. First, several studies relate crash risk to information transparency and information quality (Jin and Myers, 2006; Hutton *et al.*, 2009; Li *et al.*, 2011; Pan *et al.*, 2011; Defond *et al.*, 2015; Kim and Zhang, 2016) and to agency problems (Kim *et al.*, 2011a, b; Hong *et al.*, 2012), but few studies examine the impact of the pyramidal ownership structure. Second, abundant literature points to the common presence of the pyramidal structure in both emerging market economies and developed countries: 67% in Indonesian firms, 55% in Singaporean firms, 37% in Japanese firms, 35% in Canadian firms (Attig *et al.*, 2003), and a particular prevalence in China.[3] Meanwhile, the separation of control rights and cash flow rights caused by the pyramidal structure often leads to agency problems, namely the controlling shareholder expropriating minority shareholders (La Porta *et al.*, 1999; Johnson *et al.*, 2000; Lemmon and Lins, 2003), and damage to accounting information quality and corporate transparency (Fan and Wong, 2002; Haw *et al.*, 2004). Both of these problems may theoretically affect crash risk, but few studies explore these issues. At the same time, the reasons why a pyramidal structure exists are different for state-owned enterprises (SOEs) and non-state-owned enterprises (NSOEs) (Liu *et al.*, 2010; Fan *et al.*, 2013). Will this then lead to it having different impacts on crash risk?

To address these issues, this paper collects relevant data on the pyramidal structure of listed firms in China over the period 2001-2011 and empirically tests the relationship between a pyramidal structure and crash risk. Our findings show that, first, the pyramidal layer of SOEs can significantly reduce stock price crash risk as it can improve financial statement transparency, accounting conservatism and decrease overinvestment. Second, the greater the related party transactions, the weaker the negative correlation between the pyramidal layer and crash risk, while the negative correlation is strengthened by Hong Kong cross-listing. Further analysis shows that the corporate pyramidal layer of SOEs can also decrease stock price synchronicity. For NSOEs, we find that there is an inverse U-shaped

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[3] Liu *et al.* (2003) observe that 75.6% of Chinese firms are indirectly controlled by the government in the form of a pyramidal structure.

relationship between the corporate pyramidal layer, crash risk, and stock price synchronicity. Thus, the corporate pyramid layer is one of the main determinants of stock price crash risk, and its impact varies with the nature of the controlling shareholder.

The contributions of this paper are as follows. First, the prior literature mainly focuses on the impact of corporate pyramids on investor protection, financing, investment, tax burden, accounting information quality, performance volatility, and firm value,[4] but few studies investigate its impact on stock price crash risk. Nonetheless, crash risk, representing an extreme outcome, is helpful in understanding the true nature of crash phenomena (Kim *et al.*, 2011b). We find that the corporate pyramid structure is a new determinant of stock price crash risk, which extends the literature on crash risk (Jin and Myers, 2006; Hutton *et al.*, 2009; Kim *et al.*, 2011a, b; Li *et al.*, 2011; Pan *et al.*, 2011; Hong *et al.*, 2012; Li and Liu, 2012; Xu *et al.*, 2012; Xu *et al.*, 2013, 2014; Li *et al.*, 2014; Defond *et al.*, 2015; Kim and Zhang, 2016). Second, Hong *et al.* (2012) explore the impact of the separation of control rights and cash flow rights on crash risk by using a sample from 19 countries over the period 1995-2007. We argue that the formation and consequences of the corporate pyramid structure might be different in China compared to Western countries. Our findings differ from Hong *et al.* (2012) in several ways. We find that the correlation between the pyramidal layer and the crash risk of SOEs is negative, while Hong *et al.* (2012) find that the relationship between the separation of control rights and cash flow rights and crash risk is positive. Furthermore, the pyramidal layer of NSOEs is related to both crash risk and price synchronicity in an inverse U shape; that is, the impact of corporate pyramids on crash risk varies with the nature of the controlling shareholder, which is a new finding in the literature. Therefore, our paper facilitates a better understanding of the relationship between the pyramidal structure and crash risk. Third, the different economic consequences of pyramidal structures between SOEs and NSOEs are little examined in the literature except in Liu *et al.* (2010), who test the effect of pyramidal structures with different types of controlling shareholder on corporate performance, tunnelling, the cost of debt, and investment efficiency. Our paper provides further evidence that the impact of the pyramidal structure on crash risk varies with the nature of the controlling shareholder. Therefore, the nature of the controlling shareholder should be considered in future research in this area.

The remainder of this paper is structured as follows. Section II presents the research hypotheses. Section III discusses the research design. Section IV empirically tests and analyses the results. Section V describes our additional tests, and Section VI concludes the paper.

II. Hypotheses Development

[4] To save space, the relevant literature is not listed in detail, but this information can be provided upon request.

2.1 Pyramidal Structure of SOEs and Crash Risk

The severe degree of government control is one essential characteristic of Chinese firms. The low operational efficiency caused by government control is often criticised by the public. To improve the operational efficiency and performance of SOEs, the Chinese government has implemented a series of reforms, including devolution of power,[5] separation between government and enterprise as well as separation between control rights and cash flow rights, more control of larger enterprises and less control of small ones, and the establishment of a modern enterprise system (Liu and Li, 2012). At the same time, the continuous lengthening of the pyramidal control chains of SOEs reflects devolution of power as well as the decrease of government intervention and political costs (Liu *et al.*, 2010; Fan *et al.*, 2013). Fan *et al.* (2013) argue that local government adopts two ways to control listed firms: one commits the state asset management agency to directly control the firms, the other uses a pyramid consisting of one or more intermediate companies to indirectly control the firms. The latter arrangement makes it more difficult to interfere with firms due to the presence of intermediate firms. Why does the government devolve power through pyramidal structures? It does so because the promotion of local officials is determined critically by the development of the local economy, which requires the operational vitality of firms that results from less government intervention, thus justifying the establishment of complex pyramidal structures to inhibit government from gathering relevant information and increasing its intervention costs (Zhong *et al.*, 2010). On the basis of the theoretical explanation of "reducing government intervention" through the pyramidal structure of SOEs in Fan *et al.* (2013), some studies find that the pyramidal structure helps to promote managerial professionalism, employee efficiency, total factor productivity, and profitability (Fan *et al.*, 2013) and reduce overinvestment (Cheng *et al.*, 2008), borrowing costs (Liu *et al.*, 2010), and the tax burden (Liu and Li, 2012).

We argue that there are three main channels through which pyramidal layers might affect stock price crash risk.

First, an increase in the number of layers reduces government intervention and thereby increases corporate transparency. Bushman *et al.* (2004) suggest that financial transparency depends mainly on political factors, and financial transparency is higher in countries where the political economy is characterised by low state ownership of enterprises, low state ownership of banks, and low risk of state expropriation of firms' wealth. When firms have financial difficulties, the government gives them subsidies. Therefore, investors and creditors demand less information disclosure from firms under strict government control. Firms facing heavy government intervention have a heavy policy burden which forces them to focus on satisfying the government, such as by solving local employment issues and

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[5] The devolution of power refers to government devolving autonomous power and partial profit back to firms to incentivise them to improve their operational efficiency.

improving financial deficits, rather than on improving information transparency. Moreover, most relevant resources are held by the government. Thus, firms have an incentive to build connections with government to get preferential access to these resources, but not to enhance information transparency. Additionally, an increase in the pyramidal layers of SOEs can boost managerial professionalism (Fan *et al.*, 2013) and enhance the accuracy and reliability of disclosed information due to reduction in government intervention, thereby improving corporate information transparency. However, according to Jin and Myers (2006) and Hutton *et al.* (2009), information opaqueness blinds investors from observing firms' true performance and causes them to misprice stock, which will lead to the collapse of the stock price once real information is exposed. Therefore, the increase in the pyramidal layers of SOEs improves corporate information transparency and reduces crash risk.

Second, the increase in the number of layers reduces government intervention and thereby increases accounting conservatism. Bushman and Piotroski (2006) indicate that timely recognition of losses is obstructed by government intervention. Particularly in China, although local decentralisation enormously motivates local officials, it also stimulates them to pursue their own political ambitions and to intervene with SOEs when listed SOEs perform badly. Local officials tend to interfere in the process of producing financial reports and to encourage overestimation of corporate profits but delay loss recognition (Zhu and Li, 2008). When faced with a possible promotion, local officials tend to withhold bad news and verify corporate profits in order to maximise promotion opportunities (Piotroski *et al.*, 2015). Therefore, the increase in the number of pyramidal layers reduces government intervention, thereby increasing accounting conservatism, which decreases the crash risk (Kim and Zhang, 2016).

Third, the increase in the number of pyramidal layers reduces government intervention and thereby decreases overinvestment. The intervention of government breeds severe overinvestment in China mainly for two reasons. One reason is that local government imposes social functions on its managed SOEs, such as sound social welfare, low unemployment rate, and a stable society. This forces SOEs to set up multiple investment goals instead of pursuing the maximum net present value of investment. Consequently, the investment channel and the efficiency of SOEs are compromised and this leads to severe overinvestment. The other reason is that the government controls the appointments of CEOs in SOEs; thus, the CEOs of SOEs have the motivation to cater to the local government, and this leads to overinvestment. Cheng *et al.* (2008) find that, as one mechanism of reducing government intervention, the pyramidal structure of SOEs can effectively eliminate overinvestment. Bleck and Liu (2007) argue that when investors and shareholders fail to see through investment projects with a negative net present value due to opaque information and then force managers to give them up, bad corporate performance will accumulate and finally lead to a stock price crash. Therefore, the increase in the number of pyramidal layers of SOEs reduces overinvestment and then reduces the crash risk.

On the basis of the above analyses, this paper proposes the following hypothesis:

H1: There is a negative relation between the corporate pyramidal layer of SOEs and stock price crash risk.

2.2 Pyramidal Structure of NSOEs and Crash Risk

There is a fundamental difference between SOEs and NSOEs in terms of the formation and economic consequences of the pyramidal structure. The increase in the pyramidal layers of NSOEs enlarges the separation of control rights and cash flow rights, which reflects the agency problem between the controlling shareholders and minority shareholders, a typical agency problem among emerging market nations. The larger the separation between cash flow rights and control rights, the stronger the motivation and capacity of controlling shareholders to expropriate corporate resources and harm minority shareholders. Through the pyramidal structure, controlling shareholders can gain 100% of the benefit but bear only a portion of the loss due to the expropriation. In contrast, minority shareholders have to bear most of the loss (Johnson *et al.*, 2000; Fan and Wong, 2002; Lemmon and Lins, 2003).

The appropriation of minority shareholders' interests by controlling shareholders, once discerned, would be sanctioned by supervisory agencies and opposed by minority shareholders. To avoid this, controlling shareholders often tunnel resources out of the company in a secret way and even manipulate earnings to cover bad performance. Besides, separation of the two rights leads to stringent internal control, namely that to prevent proprietary knowledge from being exposed and attracting the attention of potential adversaries and the public, insiders would reduce information disclosure transparency (Fan and Wong, 2002). On the basis of this, some studies find that an ownership structure with the separation of the two rights damages accounting information quality and reduces corporate transparency (Fan and Wong, 2002). Using data from nine Southeast Asia countries and 14 Western European countries, Haw *et al.* (2004) show that the greater the separation, the higher the discretionary accrual. Kim and Yi (2006) find similar results from Korea that the greater the separation, the higher the discretionary accrual. Ma and Wu (2007) report that the greater the separation, the lower the tendency of listed firms to disclose information in China. Li (2008) finds that separation damages corporate information transparency more obviously in NSOEs.

On the basis of the above analyses, the greater the number of the pyramidal layers of NSOEs, the larger the separation of the two rights. This leads to a more severe agency problem and less transparent corporate information, which will lead to the higher possibility of concealing bad news. Prior literature shows that information opacity and concealing bad news are critical determinants of stock price crash risk (Jin and Myers, 2006; Hutton *et al.*, 2009). Kim *et al.* (2011a, b) also find that managers or controlling shareholders withhold bad news due to self-interest, such as cash compensation, perks, career concerns, and empire building, or the expropriation of minority shareholders' interests. Once the accumulation of bad news reaches a certain threshold, it erupts and leads to stock price crashes. Accordingly, we put forth the following hypothesis:

H2: There is a positive relation between the corporate pyramidal layer of NSOEs and stock price crash risk.

2.3 Effect of Related Party Transactions and Hong Kong Cross-Listing

Information opaqueness and corporate governance are two major factors influencing crash risk (Jin and Myers, 2006; Hutton *et al.*, 2009; Kim *et al.*, 2011a, b). Therefore, we consider the following two related factors that might impact the relationship between the pyramidal layer and crash risk: related party transactions and Hong Kong cross-listing.

2.3.1 Effect of related party transactions

Related party transactions are frequently used by controlling shareholders to expropriate minority shareholders (Johnson *et al.*, 2000; La Porta *et al.*, 2000). Some studies view related party transactions as a representation of "tunnelling". Cheung *et al.* (2006) adopt related party transactions to measure expropriation. Berkman *et al.* (2010) use related party transactions as a measure of bad corporate performance. A large number of cases also point to the severe problem of the prevalence of related party transactions in China (Chen and Wang, 2005). Yu and Xia (2004) find that related party transactions are significantly more prevalent in listed firms with controlling shareholders than in firms without controlling shareholders. Their findings show that that controlling shareholders can transfer corporate resources and expropriate minority shareholders' interests through related party transactions. Zheng (2011) suggests that one important micro mechanism of market reform and resource distribution optimisation is to reduce related party transactions and alleviate their tunnelling consequences.

Moreover, previous studies find that related party transactions have a negative impact on information quality. Huang (2001) argues that related party transactions make corporate performance change from loss to profit. Gordon and Henry (2005) find a positive relation between related party transactions and earnings management. Using the data of listed firms in China during the period 1998–2002, Jian and Wong (2010) argue that firms use related sales to manage earnings for the goal of meeting securities regulators' earnings targets and to help the listed firms maintain their listing status or qualify for rights issues. Zheng (2009) shows that the greater the number of related party transactions, the larger the earnings management and the lower the earnings-return relation. Therefore, related party transactions increase the crash risk by reducing information quality or concealing bad news.

On the basis of the above analyses, related party transactions indicate bad corporate governance and reduce accounting information quality, which might impact the relationship between the pyramidal layer and crash risk. The pyramidal layer of SOEs can reduce the political costs, but the controlling shareholders of SOEs can sometimes use the longest controlling chain to hide expropriation. If the controlling shareholders of SOEs expropriate minority shareholders through related party transactions, the effect of the pyramidal layer on increasing corporate transparency by reducing the political costs will be weakened. Therefore, related party transactions weaken the negative relation between the pyramidal layer of SOEs and crash risk. For NSOEs, more related party transactions reflect a more serious controlling shareholders' agency problem, and the pyramidal layer of NSOEs increases the crash risk due to the agency problem; thus, related party transactions strengthen the positive relation between the pyramidal layer of NSOEs and crash risk. Accordingly, we posit the following hypotheses:

H3a: The greater the related party transactions, the weaker the negative relation between the pyramidal layer of SOEs and crash risk.

H3b: The greater the related party transactions, the stronger the positive relation between the pyramidal layer of NSOEs and crash risk.

2.3.2 Effect of Hong Kong cross-listing

The term H-shares refers to shares registered in the mainland but listed in Hong Kong. H-shares differ from A-shares, which are both registered and listed in the mainland, in the following ways. First, the level of investor protection is lower in the mainland than in Hong Kong (La Porta *et al.*, 1998; Allen *et al.*, 2005). Second, the monitoring and information environment in Hong Kong is far more stringent than that in the mainland. In Hong Kong, listed firms are required to follow the International Financial Reporting Standards (IFRS) or the Generally Accepted Accounting Principles (GAAP) and to adopt Big Four auditing, but in the mainland, listed firms only need to obey Chinese accounting standards and do not necessarily need to adopt Big Four auditing (Gul *et al.*, 2010). Third, Hong Kong investors are more experienced and are more capable of collecting, dealing with, and analysing value-related information than investors in the mainland (Gul *et al.*, 2010). Therefore, the information disclosure of H-share firms is greater than that of A-share firms. In addition, foreign investors play an important role in improving corporate information transparency (Kang and Stulz, 1997) and reducing information asymmetry (Jiang and Kim, 2004).

However, Chinese SOEs listed in Hong Kong may face more government intervention. Hung *et al.* (2012) find that Chinese SOEs with strong political connections are more likely to list in Hong Kong than non-politically connected firms and that connected firms' managers list their firms in Hong Kong for private (political) benefits. These results indicate that H-share firms are more closely connected to government and may experience more government intervention.

On the basis of the above analyses, we contend that the impact of Hong Kong cross-listing on the relationship between the pyramidal layer of SOEs and crash risk is twofold. On the one hand, Hong Kong cross-listing helps to increase corporate information transparency, improve investor protection, and ensure that firms face stricter external monitoring. Then, H-share firms are less capable of concealing bad news. Therefore, the mitigating effect of the pyramidal layer of SOEs on crash risk might be weaker and the incremental effect of the pyramidal layer of NSOEs on crash risk might be limited.

On the other hand, the Hong Kong cross-listing of SOEs is the result of political considerations and may lead to more government intervention. As a result, the impact of the pyramidal layer on decreasing government intervention should be more pronounced in SOEs. This leads to a stronger negative relationship between the pyramidal layer of SOEs and crash risk.

Therefore, the net effect of Hong Kong cross-listing on the relationship between the pyramidal layer of SOEs and crash risk is unclear. It is an empirical question and we do not develop formal hypotheses.

III. Research Design

3.1 Sample and Data

The China Securities Regulatory Commission (CSRC) has required listed firms to disclose ownership information in their annual reports since 2001 (Liu *et al.*, 2010). Therefore, we select the data for the period 2001–2011 as the initial sample, and then we exclude (1) financial services firms, (2) firms with fewer than 30 trading weeks of stock return data in a fiscal year, and (3) firm-year observations with insufficient financial data to obtain control variables. The final sample includes 12,393 firm-year observations, 8,844 for SOEs and 3,549 for NSOEs. We winsorise all continuous variables at the 1% level in both tails to eliminate the impact of outliers. We collect all the data from the China Stock Market and Accounting Research (CSMAR) database except for the pyramidal layer and ownership information data for the period 2001–2003, which are manually collected from corporate annual reports.

3.2 Measuring Firm-Specific Crash Risk

Following Hutton *et al.* (2009) and Kim *et al.* (2011a, b), we employ three measures of crash risk. We first estimate firm-specific weekly returns (W) as the natural logarithm of one plus the residual return from the model below for each firm and year:

$$r_{i,t} = \alpha_i + \beta_1 r_{m,t-1} + \beta_2 r_{I,t-1} + \beta_3 r_{m,t} + \beta_4 r_{I,t} + \beta_5 r_{m,t+1} + \beta_6 r_{I,t+1} + \varepsilon_{i,t} \ , \quad (1)$$

where $r_{i,t}$ is the weekly return for stock i in week t, $r_{m,t}$ is the value-weighted average weekly market A-share return in week t, and $r_{I,t}$ is the value-weighted average weekly industry I's return in week t. We also include market and industry return $r_{m,t-1}$, $r_{m,t+1}$, $r_{I,t-1}$, $r_{I,t+1}$ for the lead period and the lag period to alleviate the bias brought about by non-synchronised trade (Dimson, 1979). The firm-specific returns of stock i in week t are measured by $W_{i,t}=Ln(1+\varepsilon_{i,t})$, with $\varepsilon_{i,t}$ denoting the residual of regression equation (1).

Second, three measures of crash risk are constructed on the basis of $W_{i,t}$.

The first measure of crash risk, denoted by *CRASH*, takes the value 1 if the firm-specific weekly return is lower than the average of all firm-specific weekly returns by 3.09 standard deviations for one week or more than one week among all weeks and 0 otherwise.

Our second measure of crash risk is the down-to-up volatility ratio, *DUVOL*, which we calculate as

$$DUVOL_{i,t} = \log\left\{\left[\left(n_u - 1\right)\sum_{DOWN} W_{i,t}^2\right]\Big/\left[\left(n_d - 1\right)\sum_{UP} W_{i,t}^2\right]\right\} , \quad (2)$$

where n_u (n_d) denotes the number of weeks in which the firm-specific weekly return $W_{i,t}$ of stock i is larger (smaller) than the annual average firm-specific weekly returns W_i. Specifically, all weeks within a specific year for firm i are categorised into two types by whether the firm-specific weekly return $W_{i,t}$ is greater than the average of all firm-specific weekly returns within that year: "down" weeks and "up" weeks. Then, we calculate the standard deviation of firm-specific weekly returns of these two types. Finally, *DUVOL* equals the natural logarithm of the ratio of the standard deviation of firm-specific weekly returns of down weeks to that of up weeks.

Our third measure of crash risk is the negative conditional return skewness, *NCSKEW*, calculated by taking the negative of the third moment of firm-specific weekly returns for each sample year and dividing it by the standard deviation of firm-specific weekly returns raised to the third power. Specifically, for each firm i in year t, we compute *NCSKEW* as

$$NCSKEW_{i,t} = -\left[n\left(n-1\right)^{3/2}\sum W_{i,t}^3\right]\Big/\left[\left(n-1\right)\left(n-2\right)\left(\sum W_{i,t}^2\right)^{3/2}\right] , \quad (3)$$

where n is the number of trading weeks of stock i annually.

3.2 Measuring Pyramidal Layer

Following Liu *et al.* (2011), Fan *et al.* (2013), and Zhang *et al.* (2016), the number of pyramidal layers (*Layer*) is measured as the number of intermediate layers of the longest chains between the ultimate controller and the company. For example, Figure 1 presents only one control chain between the ultimate controller (i.e. China Great Wall Asset Management Corporation) and the Hunan Tianyi Science and Technology Corporation, so *Layer* equals 1; Figure 2 shows two control chains between Zhang Songshan and Chongqing Huabang Pharmaceutical Corporation, so *Layer* equals 2.

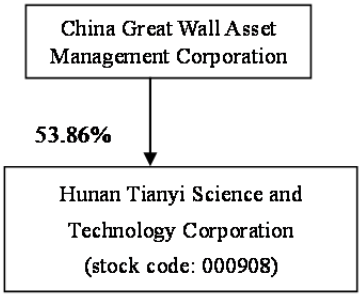

Figure 1 A one-layer structure

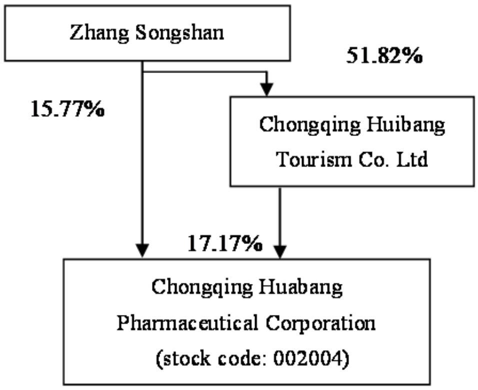

Figure 2 A two-layer structure[6]

3.3 Measuring Related Party Transactions

There are many types of related party transactions in China. Some of them can be used for the purpose of tunnelling, but others are beneficial to minority shareholders (Cheung *et al.*, 2006). Following Berkman *et al.* (2010), we exclude related party transactions that are potentially beneficial to the firm[7] from the sum of all transactions and define the remaining related party transactions divided by total assets (*RPT1*) as our first measure of related party transactions used for the purpose of tunnelling. In addition, Jian and Wong (2010) document that related sales can be used to prop up earnings for the purpose of concealing bad news. So we also use related sales divided by total assets (*RPT2*) as the second measure of related party transactions.

3.4 Measuring Hong Kong Cross-Listing

If an A-share listed firm also issues H shares, then the dummy variable *H* takes the value 1; otherwise, it takes the value 0.

3.5 Control Variables

Following Chen *et al.* (2001), Hutton *et al.* (2009), and Kim *et al.* (2011a, b), the following variables are controlled in this paper's regression model: (1) *DTURN,* the de-trended stock trading volume, calculated as the average monthly share turnover for the

[6] Note: Figure 1 and Figure 2 are adapted from the CSMAR control diagram of 2009.
[7] These include fund transactions, guarantees, or pledges and donations where the direction of the transaction is from the related party to the firm.

current fiscal year minus the average monthly share turnover for the previous fiscal year; Chen *et al.* (2001) and Kim *et al.* (2011a, b) find that where monthly share turnover is the monthly trading volume divided by the total number of floating shares on the market that month, *DTURN* is positively correlated with crash risk; (2) *SIGMA*, the standard deviation of the firm-specific weekly returns: the larger the fluctuation in firm-specific weekly returns, the higher the crash risk; (3) *RET,* the average of the firm-specific weekly returns: the higher the firm's previous stock return, the higher the future crash risk; (4) *SIZE,* the natural logarithm of the total assets at the end of the year: the larger the firm size, the higher the

Table 1 Variable Definitions

Variable	Definition
CRASH	If the firm-specific weekly return is lower than the mean of all firm-specific weekly returns by 3.09 standard deviations for 1 week or more than 1 week among all weeks, then *CRASH* takes the value 1; otherwise, it takes the value 0.
DUVOL	Down-to-up volatility. For any stock *i* in year *t*, we separate all the weeks with firm-specific weekly returns below the annual mean (down weeks) from those with firm-specific weekly returns above the period mean (up weeks) and compute the standard deviation for each of these subsamples separately. We then take the log of the ratio of the standard deviation of the down weeks to the standard deviation of the up weeks. See equation (2) for details.
NCSKEW	Negative coefficient of skewness, calculated by taking the negative of the third moment of firm-specific weekly returns for each sample year and dividing it by the standard deviation of firm-specific weekly returns raised to the third power. See equation (3) for details.
Layer	Pyramidal layer. The number of intermediate layers of the longest chains between the ultimate controller and the firm.
RPT1	The sum of the related party transactions which exclude fund transactions, guarantees, or pledges and donations divided by total assets.
RPT2	Related sales. Measured by related sales amount divided by total assets at year-end.
H	If an A-share listed firm also issues H shares, the dummy variable takes the value 1; otherwise, it takes the value 0.
DTURN	De-trended stock trading volume, calculated as average monthly share turnover for current fiscal year minus average monthly share turnover for the preceding fiscal year, where monthly share turnover is monthly trading volume divided by the total number of floating shares on the market that month.
SIGMA	Standard deviation of firm-specific weekly returns over the fiscal year.
RET	Mean of firm-specific weekly returns over the fiscal year.
SIZE	Natural logarithm of the book value of total assets.
MB	Market-to-book ratio of firm *i* in year *t*: that is, (market price at the end of fiscal year × number of shares outstanding + net asset value per share × number of non-tradable outstanding shares) / book value of equity.
LEV	Firm financial leverage, calculated as total liabilities divided by total assets.
ROA	Firm profitability, calculated as income before extraordinary items divided by total assets.
ABACC	Absolute value of discretionary accruals, where discretionary accruals are estimated from the modified Jones model (Dechow *et al.*, 1995).

crash risk; (5) *MB,* the market-to-book ratio, which is equal to (stock price at the end of the year*number of tradable shares + net assets per share*number of non-tradable shares) / book value of equity, with growth stocks more likely to crash; (6) *LEV,* leverage at year-end, and (7) *ROA,* return on assets; Hutton *et al.* (2009) find that *LEV* and *ROA* are both negatively correlated with crash risk; (8) *ABACC,* the absolute value of discretionary accruals, where discretionary accruals are estimated from the modified Jones model (Dechow *et al.*, 1995); Hutton *et al.* (2009) report that the bigger the *ABACC*, the higher the crash risk. Finally, year and industry dummy variables are included.[8] Specific definitions of the variables are listed in Table 1.

3.6 Empirical Models

Following Chen *et al.* (2001), Hutton *et al.* (2009), and Kim *et al.* (2011a, 2011b), equation (4) is constructed to test the impact of pyramidal layer on crash risk.

$$CrashRisk_{i,t+1} = \beta_0 + \beta_1 \times Layer_{i,t} + \gamma \times Control\ Variables_{i,t} + \varepsilon_{i,t}, \quad (4)$$

where $CrashRisk_{i,t+1}$ denotes crash risk at year t+1, respectively measured by three proxies, *CRASH*, *DUVOL*, and *NCSKEW*. $Control\ Variables_{i,t}$ are a group of control variables measured by the value of year t and defined as in Table 1.

When examining the impact of related party transactions and Hong Kong cross-listing on the relationship between pyramidal layer and crash risk, the following variables and interaction terms are included: $RPT1_{i,t}$ and $Layer_{i,t}*RPT1_{i,t}$, $RPT2_{i,t}$ and $Layer_{i,t}*RPT2_{i,t}$, H and $Layer_{i,t}*H$.

IV. Empirical Results and Analysis

4.1 Descriptive Statistics

Panels A and B of Table 2 present the descriptive statistics for SOEs and NSOEs, respectively. For the three measures, the crash risk of SOEs is higher than that of NSOEs. The mean for the SOE layer is 2.388, relatively lower than that for NSOEs (2.481). The ratio of SOEs issuing H shares is 3.9%, higher than that of NSOEs (0.4%). Other descriptive statistics for the control variables are listed in Table 2.

Table 3 displays the mean and median of layer distribution and corresponding crash risk. From this table, we can see that the number of layers for most of the observations is 2 or 3 for both SOEs and NSOEs. To more clearly show the relationship between pyramidal layer and crash risk, figures 3 and 4 depict the trend of crash risk for SOEs and NSOEs, respectively, as the number of pyramidal layers increases. As shown in figures 3 and 4, crash

8 The industry classification standard of the CSRC is adopted, and manufacturing industries are further categorised by the two-digit code; in total, there are 21 industries and 20 industry dummy variables.

risk decreases as the number of layers increases for SOEs, which is consistent with H1, while for NSOEs, there is an inverse U-shaped relationship between the number of layers and crash risk.

Table 2 Descriptive Statistics

	Panel A: SOEs						Panel B: NSOEs					
Variable	Obs	Mean	Median	Std	Min	Max	Obs	Mean	Median	Std	Min	Max
$CRASH_{t+1}$	8844	0.391	0.000	0.488	0.000	1.000	3549	0.383	0.000	0.486	0.000	1.000
$NCSKEW_{t+1}$	8844	0.447	0.440	0.813	-4.498	4.702	3549	0.432	0.392	0.809	-4.664	4.498
$DUVOL_{t+1}$	8844	0.355	0.359	0.592	-2.325	2.574	3549	0.331	0.312	0.583	-2.174	2.637
$Layer_t$	8844	2.388	2.000	0.880	1.000	8.000	3549	2.481	2.000	1.034	1.000	9.000
$RPT1_t$	7593	0.082	0.019	0.164	0.000	1.014	2691	0.054	0.006	0.142	0.000	1.014
$RPT2_t$	7509	0.140	0.055	0.249	0.000	1.820	2655	0.143	0.051	0.264	0.000	1.820
H_t	8844	0.039	0.000	0.194	0.000	1.000	3549	0.004	0.000	0.065	0.000	1.000
$NCSKEW_t$	8844	0.445	0.437	0.782	-1.735	2.46	3549	0.43	0.384	0.784	-1.735	2.46
$DTURN_t$	8844	0.019	0.003	0.173	-0.474	0.532	3549	0.037	0.017	0.199	-0.474	0.532
$SIGMA_t$	8844	0.045	0.042	0.019	0.008	0.298	3549	0.053	0.050	0.047	0.004	1.719
RET_t	8844	-0.001	-0.001	0.001	-0.061	0.000	3549	-0.002	-0.001	0.019	-0.674	0.000
$SIZE_t$	8844	21.553	21.437	1.097	18.948	24.657	3549	21.001	20.939	0.95	18.948	24.657
MB_t	8844	1.51	1.245	0.792	0.815	6.065	3549	1.871	1.462	1.131	0.815	6.065
LEV_t	8844	0.498	0.503	0.195	0.073	1.197	3549	0.506	0.504	0.224	0.073	1.197
ROA_t	8844	0.046	0.048	0.07	-0.294	0.279	3549	0.050	0.056	0.084	-0.294	0.279
$ABACC_t$	8844	0.061	0.042	0.063	0.001	0.356	3549	0.076	0.053	0.075	0.001	0.356

Table 3 Mean and Median of Layer Distribution and Corresponding Crash Risk

	Observations	%	$CRASH_{t+1}$		$DUVOL_{t+1}$		$NCSKEW_{t+1}$	
			Mean	Median	Mean	Median	Mean	Median
Panel A: SOEs, N=8844								
1	675	7.63%	0.412	0.000	0.419	0.405	0.515	0.528
2	5238	59.23%	0.397	0.000	0.359	0.361	0.449	0.441
3	2112	23.88%	0.386	0.000	0.340	0.358	0.435	0.438
>=4	819	9.26%	0.349	0.000	0.310	0.306	0.404	0.384
Panel B: NSOEs, N=3549								
1	392	11.05%	0.352	0.000	0.283	0.251	0.360	0.315
2	1738	48.97%	0.386	0.000	0.325	0.316	0.426	0.394
3	974	27.44%	0.396	0.000	0.357	0.340	0.459	0.419
>=4	445	12.54%	0.373	0.000	0.342	0.304	0.461	0.407

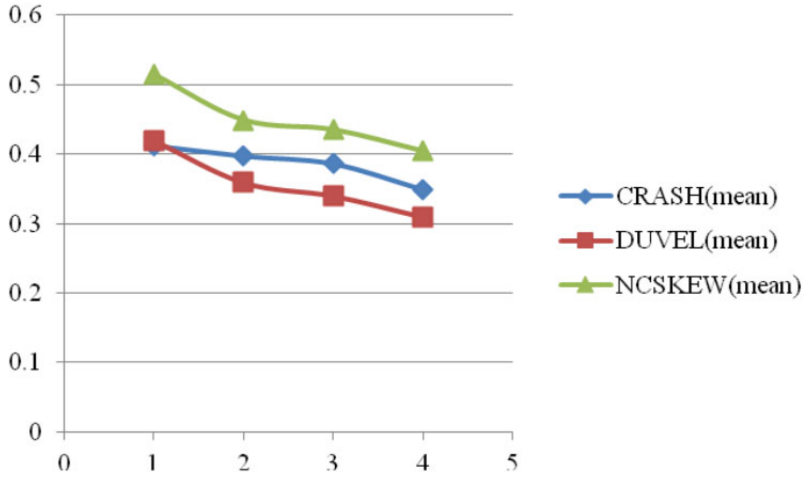

Figure 3 Pyramidal Layer of SOEs and Mean of Crash Risk

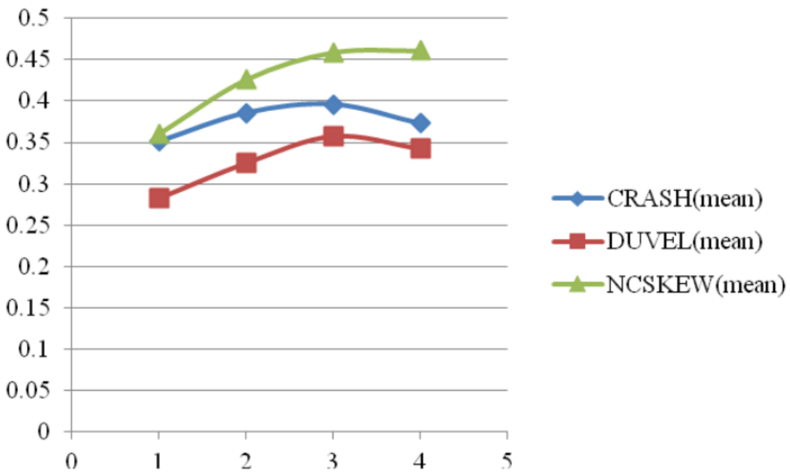

Figure 4 Pyramidal Layer of NSOEs and Mean of Crash Risk

4.2 Pyramidal Layer and Crash Risk

In Table 4, for SOEs, the coefficients on pyramidal layer in regressions (1) and (2) are -0.057 and -0.008, respectively, both significant at the 5% level. In regression (3), the coefficient is negative and also nearly significant at the 10% level, confirming that the pyramidal layer of SOEs can significantly reduce the crash risk, which is consistent with H1. This indicates that as a result of government decentralisation, the pyramidal layer of SOEs lowers government intervention, which improves information transparency and accounting conservatism and decreases overinvestment. Therefore, the pyramidal layer of SOEs reduces the crash risk.

For NSOEs, the coefficients on layer in regressions (4), (5), and (6) are all insignificant, which is inconsistent with H2. One possible reason for this is that the increase in the pyramidal layer of NSOEs may lead to greater expropriation of minority shareholders by controlling shareholders: that is, controlling shareholders engage in more stealthy ways of tunnelling, resulting in a more severe agency problem and lower information transparency. On the other hand, Gopalan and Jayaraman (2012) argue that the complexity of the ownership structure enables insiders to reduce information opaqueness and thereby to access more external financing at a lower cost. Therefore, controlling shareholders increase information disclosure to give the firm a better reputation among external investors. Thus, the impact of the pyramidal layer of NSOEs on information opaqueness depends on the balance between private benefits and external financing. Once these two effects offset each other, there is no significant relation between the pyramidal layer of NSOEs and crash risk.

Table 4 Pyramidal Layer and Stock Price Crash Risk

	SOEs			NSOEs		
	(1)	(2)	(3)	(4)	(5)	(6)
	$CRASH_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$	$CRASH_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$
$Layer_t$	-0.057**	-0.008**	-0.008	-0.053	-0.000	0.008
	(-2.25)	(-2.17)	(-1.16)	(-1.51)	(-0.04)	(0.64)
$NCSKEW_t$	0.180***	0.022*	0.032**	0.134***	0.011	0.006
	(5.51)	(1.72)	(2.06)	(2.73)	(0.73)	(0.30)
$DTURN_t$	0.121	-0.090*	-0.100	0.421	0.098	0.079
	(0.59)	(-1.88)	(-1.27)	(1.60)	(1.41)	(1.10)
$SIGMA_t$	21.832***	2.329*	2.125	0.884	-0.468	-0.489
	(4.07)	(1.87)	(1.36)	(0.47)	(-1.00)	(-0.62)
RET_t	266.309***	21.540*	21.600	2.311	-1.511	-1.904
	(3.02)	(1.77)	(1.37)	(0.53)	(-1.61)	(-1.06)
$SIZE_t$	-0.046	-0.014	-0.029	-0.109**	0.000	-0.004
	(-1.58)	(-0.84)	(-1.17)	(-2.30)	(0.02)	(-0.17)
MB_t	-0.088**	0.004	0.007	-0.171***	0.012	0.001
	(-2.23)	(0.27)	(0.40)	(-3.80)	(0.67)	(0.03)
LEV_t	-0.084	-0.013	0.065	-0.384**	-0.053	-0.043
	(-0.58)	(-0.20)	(0.69)	(-1.99)	(-1.19)	(-0.60)
ROA_t	0.045	-0.214*	-0.235	1.016**	0.011	-0.002
	(0.12)	(-1.72)	(-1.51)	(2.11)	(0.06)	(-0.01)
$ABACC_t$	0.297	0.012	0.012	1.515***	0.213*	0.340
	(0.82)	(0.08)	(0.05)	(2.90)	(1.65)	(1.48)
CONSTANT	0.264	0.679**	1.029**	2.890***	0.781**	1.067*
	(0.37)	(1.96)	(2.03)	(2.76)	(2.05)	(1.82)
INDUSTRY	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES
N	8844	8844	8844	3549	3549	3549
R^2		0.100	0.071		0.106	0.075
Pseudo R^2	0.031			0.035		

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time.

In order to prove the impact of the pyramidal layer of SOEs on crash risk through information transparency, accounting conservatism, and overinvestment, we use the following equations to test the relationship between pyramidal layer and these three variables.

$$DA_{i,t} = \beta_0 + \beta_1 \times Layer_{i,t} + \beta_2 \times SIZE_{i,t} + \beta_3 \times MB_{i,t} + \beta_4 \times LEV_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (5)$$

$$CSCORE_{i,t} = \beta_0 + \beta_1 \times Layer_{i,t} + \beta_2 \times SIZE_{i,t} + \beta_3 \times MB_{i,t} + \beta_4 \times LEV_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (6)$$

$$OVERINV_{i,t} = \beta_0 + \beta_1 \times Layer_{i,t} + \beta_2 \times SIZE_{i,t} + \beta_3 \times MB_{i,t} + \beta_4 \times LEV_{i,t} + \beta_5 \times FCF_{i,t} + \sum Industry + \sum Year + \varepsilon_{i,t} \quad (7)$$

We use the dummy variable $DA_{i,t}$ to measure financial report transparency; $DA_{i,t}$ takes the value 1 if *DiscAcc* is greater than 0, and 0 otherwise. The calculation of *DiscAcc* is as follows: First, it is estimated by the modified Jones model (Dechow *et al.*, 1995) by year and industry (see equation (8)), and then the regression coefficients estimated from equation (8) are put into equation (9) to obtain the discretionary accruals *DiscAcc*. If $DA_{i,t}$ takes the value 1, it means that the company overstates earnings to hide bad news, and so the future crash risk will be high.

$$\frac{TA_{i,t}}{Asset_{i,t-1}} = \alpha_0 \times \frac{1}{Asset_{i,t-1}} + \beta_1 \times \frac{\Delta Sales_{i,t}}{Asset_{i,t-1}} + \beta_2 \times \frac{PPE_{i,t}}{Asset_{i,t-1}} + \varepsilon_{i,t} \quad (8)$$

$$DiscAcc_{i,t} = \frac{TA_{i,t}}{Asset_{i,t-1}} - (\hat{\alpha}_0 \times \frac{1}{Asset_{i,t-1}} + \hat{\beta}_1 \times \frac{\Delta Sales_{i,t} - \Delta \mathrm{Rec}_{i,t}}{Asset_{i,t-1}} + \hat{\beta}_2 \times \frac{PPE_{i,t}}{Asset_{i,t-1}}), \quad (9)$$

where TA is total accruals, which is equal to operating profit minus cash flow from operations; $Asset_{i,t-1}$ is total assets at the end of year t-1; $\Delta Sales_{i,t}$ is the difference in total sales between the current year and the preceding year; ΔRec is accounts receivable growth; and *PPE* is gross amount of fixed assets.

We measure the degree of accounting conservatism for each firm every year using the firm-year conditional conservatism measure *CSCORE* developed by Khan and Watts (2009).

In detail, the annual cross-section regression is conducted on equation (10) to estimate coefficients λ_1, λ_2, λ_3, and λ_4, which in turn are put into equation (11) to calculate the value of *CSCORE*.

$$X_i = \beta_1 + \beta_2 \times D_i + R_i \times (\mu_1 + \mu_2 \times SIZE_i + \mu_3 \times MB_i + \mu_4 \times LEV_i) + D_i \times R_i \times (\lambda_1 + \lambda_2 \times SIZE_i + \lambda_3 \times MB_i + \lambda_4 \times LEV_i) + (\delta_1 \times SIZE_i + \delta_2 \times MB_i + \delta_3 \times LEV_i + \delta_4 \times D_i \times SIZE_i + \delta_5 \times D_i \times MB_i \; \delta_6 \times D_i \times LEV_i) + \varepsilon_i \tag{10}$$

$$CSCORE = \lambda_1 + \lambda_2 \times SIZE_i + \lambda_3 \times MB_i + \lambda_4 \times LEV_i \, , \tag{11}$$

where X_i is equal to $EPS/P_{i,t-1}$, EPS denoting earnings per share, which is equal to operating profit divided by the number of shares issued, and $P_{i,t-1}$ being the stock price at the end of the last year; and R_i is the buy-and-hold return starting from the fifth month after the fiscal year-end of period t to the fourth month into year $t+1$, adjusted by the corresponding market return. In other words, $R_i = \prod_{t,5}^{t+1,4}(1+r_{i,t}) - \prod_{t,5}^{t+1,4}(1+r_{m,t})$, where $r_{i,t}$ is monthly return of individual stocks and $r_{m,t}$ is monthly market return. When R_i is less than 0, D_i takes the value 1; otherwise, it takes the value 0. $SIZE_i$ is the natural logarithm of total assets, M/B_i is market-to-book ratio, and LEV_i is leverage.

Following Richardson (2006), we use equation (12) to estimate expected new investments, and the residuals from equation (12) are our variable of interest. If the residuals are greater than 0, the dummy variable $OVERINV_t$ takes the value 1; otherwise, it takes the value 0.

$$\begin{aligned} Inv_{i,t} = {} & \beta_0 + \beta_1 \times Q_{i,t-1} + \beta_2 \times Lev_{i,t-1} + \beta_3 \times Cash_{i,t-1} + \beta_4 \times Age_{i,t-1} \\ & + \beta_5 \times Size_{i,t-1} + \beta_6 \times \mathrm{Re}t_{i,t-1} + \beta_7 \times Inv_{i,t-1} + \sum Industry + \sum Year + \varepsilon_{i,t} \end{aligned} \tag{12}$$

where $Inv_{i,t}$ is the new investment in year t, which is equal to the change of fixed assets, construction work in progress, construction materials, intangible assets, and long-term investments divided by total assets at the beginning of the year; $Q_{i,t-1}$ is Tobin's Q in year $t-1$; $Lev_{i,t-1}$ is the leverage in year $t-1$, equal to book value of liabilities / total assets; $Cash_{i,t-1}$ is the sum of cash and cash equivalents deflated by total assets in year $t-1$; $Age_{i,t-1}$ is the number of years of being a public company as of year $t-1$; and $Ret_{i,t-1}$ is the yearly return for stock i in year $t-1$. Industry and year dummy variables are also included. In equation (7), $FCF_{i,t}$ is free cash flows, which is equal to operating cash flows deflated by total assets.

In Table 5, the coefficients on pyramidal layer in regressions (1), (2) and (3) are -0.064, 0.010, and -0.060, respectively, and are significant at the 5% level. These results suggest that the increase in the number of pyramidal layers does decrease the probability of firms overstating earnings, decrease overinvestment, and increase accounting conservatism, confirming the mediating roles of information transparency, accounting conservatism, and overinvestment incentive in the relation between pyramidal layer and crash risk.

Table 5 Pyramidal Layer and Financial Statement Transparency, Accounting Conservatism, and Overinvestment

	(1) DA_t	(2) $CSCORE_t$	(3) $OVERINV_t$
$Layer_t$	-0.064**	0.010**	-0.060**
	(-2.19)	(2.05)	(-2.29)
$SIZE_t$	-0.020	0.099***	0.067***
	(-0.60)	(14.45)	(2.69)
MB_t	0.007	0.040**	-0.034
	(0.17)	(2.39)	(-0.90)
LEV_t	-1.654***	0.507***	0.417***
	(-10.99)	(6.47)	(3.38)
FCF_t			1.677***
			(6.55)
CONSTANT	1.158	-0.882***	-1.744***
	(1.46)	(-6.12)	(-2.87)
INDUSTRY	YES	YES	YES
YEAR	YES	YES	YES
N	8844	8844	8805
R^2		0.469	
Pseudo R^2	0.020		0.024

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time. As free cash flow (FCF_t) has missing values, the observation in regression (3) is less than those in the other regressions.

4.3 Effect of Related Party Transactions and Hong Kong Cross-Listing

Considering the insignificant relationship between the pyramidal layer of NSOEs and crash risk, this paper focus on examining the impact of other factors on the relationship between pyramidal layer and crash risk only for the sample of SOEs.

4.3.1 Effect of related party transactions

Related party transactions are one way for controlling shareholders to appropriate minority shareholders' interests. Berkman *et al.* (2010) suggest that related party transactions which exclude fund transactions, guarantees, or pledges and donations where the direction of the transaction is from the related party to the firm can result in the expropriation of minority shareholders. For SOEs, related party transactions can be utilised not only for expropriation but also for government to transfer profits to listed firms. Jian and Wong (2010) find that for rights of issue stock, refinancing, and avoiding delisting, SOEs increase profits via making related party transactions to control shareholders. This behaviour conceals bad news and increases crash risk. Therefore, we investigate the impact of related party transactions (*RPT1*, *RPT2*) on the relationship between pyramidal layer and crash risk. In Table 6, most of the coefficients on the interaction term between pyramidal layer and related party transaction ($Layer_t$*$RPT1_t$, $Layer_t$*$RPT2_t$) are significantly positive, suggesting that related party transaction weakens the negative correlation between pyramidal layer and crash risk. These findings are consistent with H3a.

Table 6 Effect of Related Party Transactions

	(1) $CRASH_{t+1}$	(2) $DUVOL_{t+1}$	(3) $NCSKEW_{t+1}$	(4) $CRASH_{t+1}$	(5) $DUVOL_{t+1}$	(6) $NCSKEW_{t+1}$
$Layer_t$	-0.062**	-0.017***	-0.018***	-0.075**	-0.020***	-0.022***
	(-2.45)	(-8.66)	(-3.41)	(-2.49)	(-6.86)	(-3.06)
$Layer_t$*$RPT1_t$	0.162	0.067**	0.097*			
	(1.36)	(2.51)	(1.77)			
$RPT1_t$	-0.457*	-0.201**	-0.299**			
	(-1.70)	(-2.35)	(-1.97)			
$Layer_t$*$RPT2_t$				0.155**	0.056***	0.077***
				(2.45)	(3.97)	(2.71)
$RPT2_t$				-0.514***	-0.169***	-0.260***
				(-2.63)	(-3.69)	(-3.26)
$NCSKEW_t$	0.052*	0.027***	0.036**	0.051*	0.027***	0.036**
	(1.76)	(2.64)	(2.49)	(1.77)	(2.64)	(2.45)
$DTURN_t$	-0.129	-0.059	-0.057	-0.142	-0.062	-0.070
	(-0.54)	(-1.20)	(-0.74)	(-0.56)	(-1.22)	(-0.89)
$SIGMA_t$	-0.279	1.988	1.962	0.314	2.032*	2.084
	(-0.10)	(1.60)	(1.10)	(0.11)	(1.66)	(1.18)
RET_t	-1.138	19.517	21.317	2.515	20.035*	22.251
	(-0.05)	(1.62)	(1.22)	(0.11)	(1.65)	(1.27)
$SIZE_t$	-0.070	-0.014	-0.025	-0.068	-0.014	-0.025
	(-1.37)	(-0.75)	(-0.92)	(-1.34)	(-0.77)	(-0.92)
MB_t	-0.024	0.008	0.015	-0.023	0.009	0.017
	(-0.86)	(0.48)	(0.74)	(-0.77)	(0.60)	(0.84)
LEV_t	0.100	-0.016	0.046	0.101	-0.011	0.050
	(0.52)	(-0.24)	(0.46)	(0.57)	(-0.16)	(0.50)
ROA_t	-0.016	-0.118	-0.129	-0.001	-0.135	-0.149
	(-0.03)	(-0.86)	(-0.78)	(-0.00)	(-0.92)	(-0.84)
$ABACC_t$	0.396	0.081	0.118	0.388	0.075	0.118
	(1.03)	(0.57)	(0.59)	(0.99)	(0.52)	(0.59)
CONSTANT	1.492	0.630	0.967	1.445	0.841**	1.157**
	(1.38)	(1.48)	(1.56)	(1.35)	(2.14)	(2.00)
INDUSTRY	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES
N	7593	7593	7593	7509	7509	7509
R^2		0.103	0.074		0.103	0.075
Pseudo R^2	0.026			0.026		

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time.

4.3.2 Effect of Hong Kong cross-listing

To examine the effect of Hong Kong cross-listing on the relationship between pyramidal layer and crash risk, we include a dummy variable of H shares (*H*) and the interaction between pyramidal layer and the H-share dummy variable ($Layer_t*H$) in the regressions. In Table 7, the coefficients on $Layer_t*H$ in regressions (1) and (3) are -0.308 and -0.069, significant at the 10% and 1% levels, respectively. This indicates that Hong Kong cross-listing helps to strengthen the negative relationship between the pyramidal layer of SOEs and crash risk.

Table 7 Effect of Hong Kong Cross-Listing

	(1) $CRASH_{t+1}$	(2) $DUVOL_{t+1}$	(3) $NCSKEW_{t+1}$
$Layer_t$	-0.047*	-0.007*	-0.005
	(-1.86)	(-1.96)	(-0.85)
$Layer_t*H$	-0.279*	-0.034	-0.069***
	(-1.82)	(-1.17)	(-2.62)
H	0.725*	0.086	0.175**
	(1.84)	(0.89)	(2.08)
$NCSKEW_t$	0.180***	0.022*	0.032**
	(5.51)	(1.71)	(2.04)
$DTURN_t$	0.129	-0.090*	-0.099
	(0.62)	(-1.85)	(-1.24)
$SIGMA_t$	21.672***	2.320*	2.108
	(4.05)	(1.84)	(1.34)
RET_t	264.535***	21.478*	21.484
	(3.01)	(1.75)	(1.35)
$SIZE_t$	-0.055*	-0.015	-0.031
	(-1.85)	(-0.83)	(-1.13)
MB_t	-0.090**	0.004	0.007
	(-2.29)	(0.25)	(0.37)
LEV_t	-0.075	-0.011	0.067
	(-0.52)	(-0.18)	(0.70)
ROA_t	0.055	-0.213*	-0.233
	(0.15)	(-1.69)	(-1.43)
$ABACC_t$	0.295	0.012	0.011
	(0.81)	(0.08)	(0.05)
CONSTANT	0.467	0.700*	1.068*
	(0.64)	(1.85)	(1.89)
INDUSTRY	YES	YES	YES
YEAR	YES	YES	YES
N	8844	8844	8844
R^2		0.100	0.072
Pseudo R^2	0.031		

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The Z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time.

4.4 Robustness Tests

4.4.1 Endogeneity issue

Although the dependent variable (crash risk) of the regression model takes the value of *t+1* period and the independent variable (pyramidal layer) takes the value of *t* period, which might alleviate endogeneity problems, there is still a potential endogeneity issue between pyramidal layer and crash risk. To further address this concern, we use instrumental

Table 8 Pyramidal Layer and Stock Price Crash Risk: 2SLS Estimation

	1st Stage	2nd Stage		
	$Layer_t$	$CRASH_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$
$Number\ of\ Sea\ Ports_t$	0.005***			
	(2.92)			
$Commercial\ Port_t$	-0.133***			
	(-4.32)			
$Leased\ Territories_t$	0.085***			
	(2.98)			
$Predicted\ Layer_t$		-0.363**	-0.494***	-0.625**
		(-2.55)	(-2.77)	(-2.54)
$NCSKEW_t$	-0.002	0.014*	0.020**	0.030**
	(-0.18)	(1.75)	(1.99)	(2.19)
$DTURN_t$	-0.096	-0.073	-0.135*	-0.158*
	(-1.12)	(-1.31)	(-1.93)	(-1.72)
$SIGMA_t$	4.472***	1.388	4.500***	4.924****
	(3.93)	(1.36)	(3.51)	(2.85)
RET_t	33.239***	10.61	37.714***	42.661***
	(3.83)	(1.16)	(3.18)	(2.72)
$SIZE_t$	-0.003	-0.022***	-0.015*	-0.030**
	(-0.28)	(-3.01)	(-1.66)	(-2.47)
MB_t	-0.009	-0.015	-0.000	0.002
	(-0.52)	(-1.35)	(-0.00)	(0.11)
LEV_t	-0.011	0.018	-0.022	0.051
	(-0.18)	(0.45)	(-0.44)	(0.76)
ROA_t	-0.126	-0.065	-0.267**	-0.309*
	(-0.81)	(-0.64)	(-2.06)	(-1.79)
$ABACC_t$	0.105	0.138	0.062	0.077
	(0.64)	(1.31)	(0.46)	(0.43)
CONSTANT	2.369***	1.746***	1.679***	2.390***
	(8.87)	(4.62)	(3.55)	(3.69)
INDUSTRY	YES	YES	YES	YES
YEAR	YES	YES	YES	YES
N	8844	8844	8844	8844
R^2	0.063	-	-	-
Predictive Power of Excluded Instruments				
Partial-R^2	0.002			
Robust F-statistic (instruments)	7.587			
F-statistic p-value	0.000			
Test of Over-identifying Restrictions				
Hansen J-statistic		1.597	4.607	1.473
p-value		0.450	0.100	0.479

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. z-statistics (t-statistics) are reported in parentheses. There is an R^2 missing phenomenon in the second stage of 2SLS.

Table 9 Alternative Measures of Pyramidal Layer

	(1)	(2)	(3)	(4)	(5)	(6)
	$CRASH_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$	$CRASH_{t+1}$	$DUVOL_{t+1}$	$NCSKEW_{t+1}$
Separation	-0.010***	-0.002**	-0.004**			
	(-2.80)	(-2.05)	(-2.46)			
Co				-0.097**	-0.016*	-0.029**
				(-2.24)	(-1.89)	(-2.20)
CF[9]	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(-0.86)	(-1.33)	(-1.50)	(-0.78)	(-1.48)	(-1.41)
$NCSKEW_t$	0.064**	0.024***	0.034**	0.062*	0.023*	0.032**
	(2.04)	(2.89)	(2.42)	(1.93)	(1.91)	(2.24)
$DTURN_t$	-0.213	-0.104*	-0.147	-0.232	-0.109*	-0.144
	(-0.97)	(-1.85)	(-1.46)	(-1.03)	(-1.73)	(-1.43)
$SIGMA_t$	0.076	2.449***	2.189	0.419	2.483**	2.228
	(0.02)	(2.65)	(1.63)	(0.12)	(2.22)	(1.56)
RET_t	23.530	25.261**	24.662**	27.882	25.394**	24.374**
	(0.58)	(2.28)	(2.10)	(0.63)	(2.44)	(2.07)
$SIZE_t$	-0.093***	-0.017**	-0.032	-0.091***	-0.015	-0.029
	(-3.32)	(-2.19)	(-1.28)	(-3.22)	(-0.90)	(-1.21)
MB_t	-0.055	-0.005	-0.002	-0.056	-0.002	0.003
	(-1.36)	(-0.45)	(-0.09)	(-1.33)	(-0.14)	(0.16)
LEV_t	0.177	-0.001	0.098	0.167	-0.007	0.081
	(1.23)	(-0.03)	(0.92)	(1.14)	(-0.10)	(0.84)
ROA_t	0.297	-0.073	-0.034	0.100	-0.134	-0.145
	(0.75)	(-0.70)	(-0.17)	(0.25)	(-1.05)	(-0.90)
$ABACC_t$	0.523	-0.015	0.017	0.449	-0.015	-0.005
	(1.28)	(-0.14)	(0.08)	(1.09)	(-0.09)	(-0.02)
CONSTANT	1.701**	0.801***	1.154**	1.962***	0.770**	1.117**
	(2.49)	(4.68)	(2.26)	(2.80)	(2.23)	(2.25)
INDUSTRY	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES
N	7967	7967	7967	7778	7778	7778
R^2		0.104			0.105	0.075
Pseudo R^2	0.030		0.075	0.029		

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time. For the reason that control rights and cash flow rights have missing values, this table's observations are not consistent with the main text.

variables to conduct two-stage least squares regressions (2SLS). Fan *et al.* (2013) argue that institutional environment is an important factor in determining the pyramidal layer, while Piotroski and Wong (2011) stress the significance of institutions for the information

[9] *CF* is cash-flow rights; this control variable is included according to Liu *et al.* (2012).

environment. Therefore, the relationship between pyramidal layer and crash risk may be determined by the institutional environment, which results in a spurious correlation. Thus, following Fan *et al.* (2013), the number of $Sea\ Ports_t$, $Commercial\ Port_t$, and $Leased\ Territories_t$[10] are selected as three instrumental variables for t to conduct 2SLS estimations.

Table 8 reports the two-stage regression results. Three instrumental variables in the first stage are all significantly correlated with the pyramidal layer. F-statistics and Hansen J-statistics suggest that the instrumental variables satisfy the validity requirement and exclusion restriction. More importantly, *Predicted Layer* and crash risk are still significantly negatively correlated in the second stage. This indicates that our conclusion is robust to the potential endogeneity concern.

4.4.2 Alternative measures of pyramidal layer

We use two alternative measures of pyramidal layer, the level of separation between control rights and cash flow rights (*Separation*) and the ratio of controlling shareholders' control rights to cash flow rights (*Co*), to conduct a robustness check. The regression results in Table 9 show that *Separation* is significantly negatively correlated with crash risk at the 5% level and that *Co* is also significantly negatively correlated with crash risk at the 1%, 5%, and 10% levels. These results suggest that that the more serious the separation, the lower the crash risk, consistent with our findings in Table 4.

4.4.3 Alternative measure of related party transactions

Jian and Wong (2010) argue that there are normal and abnormal related party transactions. We use the same method as Jian and Wong (2010) to delete factors such as industry, time, and firm characteristics (i.e. firm size, leverage, and market-to-book ratio) from the related party transactions, with the residual used as a proxy for the abnormal related party transactions ($ABRPT1_t$, $ABRPT2_t$). The regressions in Table 10 confirm that almost all of the coefficients on the interaction between pyramidal layer and abnormal related party transactions ($Layer_t*ABRPT1_t$, $Layer_t*ABRPT2_t$) are significantly positive. This does not alter our previous results.

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[10] $Number\ of\ Sea\ Ports_t$ refers to the number of seaports within the province, region, or municipality where our sampled listed firms are located. $Commercial\ Port_t$ and $Leased\ Territories_t$ are dummy variables. If the province, region, or municipality where our sampled listed firms are located opens sea or inland river ports or leased territories to foreigners after the First Opium War in 1842 during the Qing Dynasty, these variables take the value 1; otherwise, they take the value 0. Following Fan *et al.* (2013), the provinces, regions, or municipalities where treaty ports are located include Fujian, Guangdong, Shanghai, and Zhejiang (Treaty of Nanjing 1842); Fujian, Hainan, Hubei, Guangdong, Jiangsu, Liaoning, and Shandong (Treaty of Tianjin 1858); Tianjin and Xinjiang (Treaty of Beijing 1860); Anhui, Hubei, Guangxi, and Zhejiang (Treaty of Yantai 1876); and Chongqing, Hubei, and Zhejiang (Treaty of Maguan, 1895); and the provinces, regions, or municipalities where leased territories are located include Tianjin (1860), Shanghai (1845), Jiangsu (1863), Zhejiang (1896), Anhui (1877), Jiangxi (1861), Fujian (1861), Shandong (1889), Guangdong (1857), Chongqing (1901), and Hubei (1861).

Table 10 Alternative Measure of Related Party Transactions

	(1) $CRASH_{t+1}$	(2) $DUVOL_{t+1}$	(3) $NCSKEW_{t+1}$	(4) $CRASH_{t+1}$	(5) $DUVOL_{t+1}$	(6) $NCSKEW_{t+1}$
$Layer_t$	-0.050*	-0.012***	-0.011*	-0.053*	-0.012***	-0.011
	(-1.80)	(-3.95)	(-1.65)	(-1.80)	(-3.46)	(-1.63)
$Layer_t$*$ABRPT1_t$	0.144	0.086***	0.113**			
	(1.12)	(3.16)	(2.23)			
$ABRPT1_t$	-0.412	-0.247***	-0.339**			
	(-1.37)	(-2.94)	(-2.46)			
$Layer_t$*$ABRPT2_t$				0.146**	0.065***	0.083***
				(2.21)	(4.76)	(2.66)
$ABRPT2_t$				-0.489**	-0.192***	-0.276***
				(-2.38)	(-4.38)	(-3.28)
$NCSKEW_t$	0.052*	0.022**	0.036**	0.051*	0.027***	0.036**
	(1.75)	(2.16)	(2.47)	(1.77)	(2.62)	(2.44)
$DTURN_t$	-0.130	-0.052	-0.057	-0.142	-0.062	-0.070
	(-0.55)	(-1.09)	(-0.74)	(-0.56)	(-1.21)	(-0.88)
$SIGMA_t$	-0.265	5.131*	1.961	0.293	2.022*	2.072
	(-0.09)	(1.94)	(1.10)	(0.10)	(1.66)	(1.17)
RET_t	-1.001	79.498*	21.303	2.422	19.966*	22.175
	(-0.05)	(1.73)	(1.22)	(0.11)	(1.65)	(1.27)
$SIZE_t$	-0.070	-0.013	-0.026	-0.068	-0.014	-0.025
	(-1.40)	(-0.73)	(-0.95)	(-1.36)	(-0.78)	(-0.93)
MB_t	-0.025	0.008	0.014	-0.026	0.008	0.015
	(-0.85)	(0.48)	(0.70)	(-0.87)	(0.54)	(0.74)
LEV_t	0.102	-0.018	0.048	0.087	-0.014	0.043
	(0.53)	(-0.26)	(0.48)	(0.48)	(-0.21)	(0.42)
ROA_t	-0.017	-0.120	-0.130	-0.000	-0.134	-0.149
	(-0.04)	(-0.88)	(-0.79)	(-0.00)	(-0.92)	(-0.83)
$ABACC_t$	0.395	0.072	0.117	0.388	0.075	0.118
	(1.03)	(0.51)	(0.59)	(0.99)	(0.52)	(0.59)
CONSTANT	1.477	0.539	0.960	1.412	0.826**	1.140**
	(1.39)	(1.17)	(1.57)	(1.33)	(2.10)	(2.00)
INDUSTRY	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES
N	7593	7593	7593	7509	7509	7509
R^2		0.103	0.075		0.103	0.075
Pseudo R^2	0.026			0.026		

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time.

4.4.4 Including additional control variables

Kim *et al.* (2011a, b) and Kim and Zhang (2016) find that tax avoidance, equity incentive, and accounting conservatism affect crash risk. Therefore, we further control for these three factors. We use *BTD*, *MHOLDRATE*, and *CSCORE* to measure tax avoidance, equity incentive, and accounting conservatism. *BTD*[11] is equal to (pre-tax income - current income tax expense / nominal income tax rate) / total assets. *MHOLDRATE* is the shares held by management divided by total shares.

Table 11 shows that for SOEs, the coefficients of *Layer* are still significantly positive, but for NSOEs, they are still insignificant. These results suggest that the conclusion in Table 4 is qualitatively unchanged after controlling for factors such as tax avoidance, equity incentive, and accounting conservatism.[12]

Table 11 Including Additional Control Variables

	SOEs			NSOEs		
	(1) $CRASH_{t+1}$	(2) $DUVOL_{t+1}$	(3) $NCSKEW_{t+1}$	(4) $CRASH_{t+1}$	(5) $DUVOL_{t+1}$	(6) $NCSKEW_{t+1}$
$Layer_t$	-0.071***	-0.010*	-0.010	-0.029	-0.008	-0.005
	(-2.71)	(-1.86)	(-1.30)	(-0.71)	(-0.80)	(-0.40)
$NCSKEW_t$	0.192***	0.020	0.030*	0.104**	0.010	0.007
	(5.61)	(1.53)	(1.84)	(2.00)	(0.64)	(0.35)
$DTURN_t$	0.137	-0.102**	-0.114	0.418	0.018	-0.018
	(0.63)	(-2.34)	(-1.59)	(1.48)	(0.21)	(-0.18)
$SIGMA_t$	23.032***	2.573**	2.488	1.126	-0.400	-0.378
	(4.01)	(2.09)	(1.57)	(0.61)	(-0.79)	(-0.44)
RET_t	281.927***	25.11**	25.650*	2.591	-1.297	-1.608
	(2.96)	(2.28)	(1.72)	(0.59)	(-1.30)	(-0.82)
$SIZE_t$	-0.063**	-0.013	-0.030	-0.053	0.005	0.002
	(-2.13)	(-0.76)	(-1.18)	(-1.02)	(0.29)	(0.07)
MB_t	-0.082**	0.006	0.009	-0.181***	0.018	0.009
	(-1.98)	(0.43)	(0.57)	(-3.65)	(1.20)	(0.47)
LEV_t	-0.063	-0.000	0.085	-0.441**	-0.063*	-0.077
	(-0.41)	(-0.00)	(0.83)	(-2.09)	(-1.71)	(-1.00)
ROA_t	-0.603	-0.381**	-0.446*	1.826***	-0.120	-0.142
	(-1.21)	(-2.02)	(-1.84)	(2.68)	(-0.53)	(-0.31)
$ABACC_t$	0.363	0.023	0.003	1.209**	0.196	0.300
	(0.95)	(0.15)	(0.02)	(2.20)	(1.27)	(1.16)
$CSCORE_t$	0.055	-0.031**	-0.048***	-0.120	-0.064*	-0.057*
	(1.46)	(-1.98)	(-3.02)	(-1.43)	(-1.87)	(-1.73)
BTD_t	0.889*	0.167	0.195	-1.115*	0.223	0.143
	(1.89)	(0.83)	(0.95)	(-1.70)	(1.21)	(0.49)
$MHOLDRATE_t$	1.178	-0.275	-0.294	0.287	-0.163**	-0.246***
	(0.79)	(-0.70)	(-0.64)	(0.98)	(-2.30)	(-4.15)
CONSTANT	0.606	0.707*	1.111**	1.822	0.795**	1.097*
	(0.81)	(1.88)	(2.08)	(1.57)	(2.04)	(1.90)
INDUSTRY	YES	YES	YES	YES	YES	YES
YEAR	YES	YES	YES	YES	YES	YES
N	8169	8169	8169	3200	3200	3200
R^2		0.100	0.072		0.109	0.076
Pseudo R^2	0.033			0.037		

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time. For the reason that $CSCORE_t$, BTD_t, and $MHOLDRATE_t$ have missing values, this table's observations are not consistent with the main text.

[11] We use ETR Differential and DD_BTD from Kim *et al.* (2011a) to measure tax avoidance; we obtain the same results.

[12] Other regression results are basically unchanged, and we can provide them on request.

V. Additional Tests

5.1 Pyramidal Layer and Stock Price Synchronicity

Another issue closely related to crash risk is stock price synchronicity, which reflects stock pricing efficiency. Stock price synchronicity measures the extent of firm-specific information reflected in stock price, with a low degree of reflection corresponding to high price synchronicity (Morck *et al.*, 2000). Therefore, it is also considered as a proxy for corporate information quality. Thus, an interesting question is whether pyramidal layers also affect stock price synchronicity. We argue that, for SOEs, pyramidal layer reduces government control and decreases government expropriation and social burden for the corporation. Firms with more layers need to disclose more information if they want to obtain more external financing at lower cost. So, the pyramidal layer increases information transparency and decreases stock price synchronicity. Thus, we predict that there is a negative correlation between pyramidal layer and stock price synchronicity. For NSOEs, the pyramidal layer reflects the agency problem of controlling shareholders because the separation of control rights and cash flow rights increases with the number of pyramidal layers. So, the greater the number of pyramidal layers, the more severe the expropriation of minority shareholders by controlling shareholders. Thus, the pyramidal layer increases stock

Table 12 Pyramidal Layer and Stock Price Synchronicity

	SOEs	NSOEs
	(1)	(2)
	SYN_t	SYN_t
$Layer_t$	-0.040***	0.029
	(-3.01)	(1.29)
$SIZE_t$	-0.016	0.047
	(-0.38)	(1.42)
MB_t	-0.214***	-0.185***
	(-4.94)	(-5.98)
LEV_t	-0.283**	-0.388**
	(-2.38)	(-2.50)
ROA_t	0.961***	1.079**
	(3.08)	(2.25)
Var(industry return)[13]	-8.415***	-2.208
	(-3.09)	(-0.47)
CONSTANT	6.098***	4.558***
	(7.31)	(6.34)
INDUSTRY	YES	YES
YEAR	YES	YES
N	8844	3549
R^2	0.262	0.225

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The t-statistics reported in parentheses are based on standard errors clustered by both firm and time.

[13] This is the variance of the weekly returns of the industry during the firm's fiscal year. This control variable is included following Hutton *et al.* (2009).

price synchronicity. However, tunnelling behaviour depends on its benefit and cost because expropriation by the shareholders can be expected. Firms at the bottom of the pyramids need to disclose more firm-specific information if they want to obtain the same financing at the same cost as the firms at the top of the pyramids. Otherwise, investors will provide less financing at a higher cost. Therefore, the relationship between the pyramidal layer of NSOEs and stock price synchronicity is an empirical issue.

Following Hutton *et al.* (2009), the R^2 obtained from model (1) is used to estimate stock price synchronicity. The value range of R^2 is [0, 1], which does not satisfy the requirement of OLS; thus, its logarithmic transformation is taken:

$$SYN = Ln\left(\frac{R^2}{1-R^2}\right) \quad (13)$$

The regression results in Table 12 show that the pyramidal layer of SOEs is negatively correlated with stock price synchronicity and significant at the 1% level, while that of NSOEs is not significant. Therefore, the pyramidal layer of SOEs significantly reduces stock price synchronicity, further validating the previous conclusion related to the relationship between pyramidal layer and stock price crash risk.

5.2 Non-Linear Tests on the Relation between the Pyramidal Layer of NSOEs, Stock Price Synchronicity, and Crash Risk

In previous tests, it is shown that the pyramidal layer of NSOEs is not monotonically linearly correlated with crash risk and stock price synchronicity. We predict that there might be an inverse U-shaped relationship because whether the pyramidal layer improves information transparency depends on the benefit and cost of improving information transparency for the controlling shareholder. Before the pyramidal layer reaches a certain number, the controlling shareholder would expropriate minority shareholders by decreasing information transparency because the benefit from tunnelling exceeds the benefit of increasing information transparency. Then, the pyramidal layer is positively correlated with crash risk and stock price synchronicity. Beyond a certain number of pyramidal layers, minority shareholders could expect that the separation between control rights and cash flow rights would be very serious; therefore, an increase in information transparency would serve as a credible commitment made by controlling shareholders toward creating a reputation of not expropriating the interests of minority shareholders. In addition, in order to obtain more external financing from outside investors at a lower cost, controlling shareholders would improve information transparency; furthermore, as outside investors think that the agency problem is very serious, controlling shareholders would have to increase information transparency to gain more trust from these investors. Therefore, pyramidal layer would be negatively correlated with both crash risk and stock price synchronicity.

Accordingly, we include the square of the layer ($LayerSqure_t$) in the model, and the results are presented in Table 13. The coefficients on the layer ($Layer_t$) in (1)–(4) are all significantly positive, but the coefficients on the square term ($LayerSqure_t$) are all significantly negative. These results indicate that pyramidal layer is correlated with both crash risk and stock price synchronicity in the shape of an inverse U.

Table 13 Non-linear Tests on Pyramidal Layer with Stock Price Synchronicity and Crash Risk

	(1) $CRASH_{t+1}$	(2) $DUVOL_{t+1}$	(3) $NCSKEW_{t+1}$	(4) SYN_t
$Layer_t$	0.212**	0.055*	0.066*	0.107**
	(2.24)	(1.76)	(1.74)	(2.28)
$LayerSqure_t$	-0.034**	-0.008**	-0.009*	-0.012*
	(-1.96)	(-2.10)	(-1.88)	(-1.75)
$NCSKEW_t$	0.024	0.011	0.005	
	(0.60)	(0.71)	(0.28)	
$DTURN_t$	0.304	0.096	0.077	
	(1.19)	(1.37)	(1.04)	
$SIGMA_t$	-2.327**	-0.474	-0.496	
	(-2.22)	(-0.99)	(-0.63)	
RET_t	-7.195***	-1.514	-1.907	
	(-2.61)	(-1.60)	(-1.07)	
$SIZE_t$	-0.053	-0.001	-0.006	0.045
	(-1.30)	(-0.06)	(-0.23)	(1.36)
MB_t	-0.047	0.012	0.000	-0.186***
	(-0.80)	(0.64)	(0.01)	(-5.99)
LEV_t	-0.077	-0.061	-0.051	-0.399***
	(-0.36)	(-1.36)	(-0.71)	(-2.58)
ROA_t	0.806	0.020	0.008	1.091**
	(1.28)	(0.11)	(0.03)	(2.28)
$ABACC_t$	1.141**	0.213*	0.341	
	(2.17)	(1.67)	(1.49)	
Var(industry return)				-2.320
				(-0.49)
CONSTANT	1.245	0.727*	1.012*	4.486***
	(1.45)	(1.95)	(1.74)	(6.46)
INDUSTRY	YES	YES	YES	YES
YEAR	YES	YES	YES	YES
N	3549	3549	3549	3549
R^2		0.107	0.076	0.225
Pseudo R^2	0.028			

Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The z-statistics (t-statistics) reported in parentheses are based on standard errors clustered by both firm and time.

VI. Conclusions and Implications

This paper collects relevant data on the pyramidal structure of listed firms in China for the period 2001–2011 and investigates the impact of pyramidal structure on stock price crash risk and how the nature of the controlling shareholder affects this relationship. We find that the pyramidal layer of SOEs can significantly reduce the crash risk; this is due to the fact that the pyramidal layer of SOEs can improve financial statement transparency, increase accounting conservatism, and decrease the level of overinvestment. In addition, for SOEs, the greater the number of related party transactions, the weaker the negative correlation between the pyramidal layer and crash risk, and this negative correlation can be strengthened by Hong Kong cross-listing. Further analysis shows that the corporate pyramidal layer of SOEs also decreases stock price synchronicity, but for NSOEs, there is an inverse U-shaped relationship between corporate pyramidal layer, crash risk, and stock price synchronicity. Therefore, the pyramidal structure is one of the main determinants of crash risk in China, and its impact varies with the nature of the controlling shareholder.

Our conclusions have important policy implications. First, we find that an increase in the number of pyramidal layers can reduce crash risk for SOEs, which indicates that the pyramidal layer might reduce government intervention, and reducing government intervention can improve the corporate information environment and stock price information efficiency. Second, our results suggest that stricter regulation over related party transactions, better legal investor protection, and a better information environment are helpful in reducing the stock price crash risk.

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