

# Effects of Venture Capital, R&D, and Technology on IPO Underpricing: Evidence from China

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**Abstract:** **Research Question:** This study is a preliminary attempt to investigate the effects of technology and R&D expenditure and the moderating effect of venture capital through the interaction of technology and R&D on the underpricing of IPOs in China's A-share market. **Motivation:** The role of technology in IPO underpricing and the moderating influence of venture capital, R&D, and technology on underpricing of IPO have not been studied; thus, this research aims to fill this gap. **Idea:** High-tech firms experience higher IPO underpricing. Venture capital can help to reduce the high-technology IPOs' underpricing by reducing the uncertainty associated with tech-IPOs. IPOs with higher R&D expenditure experience higher IPO underpricing. Venture capital can help release the uncertainty faced by IPOs with high R&D and reduce the underpricing of such IPOs. **Data:** The data represent all IPOs in China's A-share market from SSE and SZSE for the 2013–2018 period. Our sample includes a total of 997 IPOs, excluding financial company IPOs and IPOs without integrated data. **Method/Tools:** We apply a cross-product residual centering approach to explore the relationships among factors. **Findings:** We find that venture-backing IPOs experience less underpricing, technology requirement increases IPO underpricing, and R&D expenditure helps to reduce tech-IPO underpricing. The striking observation that has emerged from the data is that IPO underpricing caused by technology requirement can be moderated by the participation of venture capital. The finding highlights that strengthening the supervision role of venture capital in the invested company and improving the R&D information disclosure level in a technology company can effectively reduce the degree of IPO underpricing. **Contributions:** Our research focuses on all IPOs from China's A-share market, indicating an expanded sample size. More importantly, this study offers new insights by illustrating the interaction effect between R&D and technology on IPO underpricing as a means of explaining the moderation influence of venture capitalists on IPO underpricing.

**Keywords:** Initial public offering, venture capital, technology, R&D expenditure, underpricing, VC-backed IPO.

**JEL Classification:** G20, G23, G24

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Received 20 Oct 2020; Final revised 31 Mar 2021; Accepted 3 May 2021; Available online 30 Sep 2021.

To link to this article: [https://www.mfa.com.my/cmrv/v29\\_i2\\_a2/](https://www.mfa.com.my/cmrv/v29_i2_a2/)

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## 1. Introduction

Initial public offering (IPO) underpricing has generated significant interests of practitioners. Since Ibbotson (1975) discovered this phenomenon for the first time in 1975, many scholars have studied stock markets in different periods and different regions and found that IPO underpricing is a highly usual phenomenon in all capital markets all over the world, but the degree of underpricing is different. Usually, IPO underpricing in a developing country's stock market is more serious than those in developed countries. Most of models and theories account for the phenomenon based on information asymmetry and agency theory.

The role of government has led China's IPO market to manifest certain characteristics with respect to other stock markets. The China Securities Regulatory Commission plays an essential role in the IPO pricing process. China's domestic research on IPO underpricing is mainly divided in two parts. Jiang *et al.* (2014) combined China's institutional background to investigate IPO underpricing, showing that institutional factors are the main reason for the high underpricing of IPO in China. Meanwhile, Su (2004) followed the Western research approach and suggested that the level of information asymmetry also significantly affects the level of underpricing of China IPOs.

Among the factors that influence IPO underpricing, R&D expenditure, venture capitalists, and technology have been widely examined by some scholars. Research and development (R&D) expenditure is considered a high-risk investment and is a discretionary strategy. R&D expenditure is especially crucial for IPO firms because IPO firms are mostly young and entrepreneurial and because IPO underpricing is related to R&D intensity (Kao and Chen, 2020). For the research on USA-listed companies, Heeley and Jain (2007) and Guo *et al.* (2006) found that an increase in R&D expenditure leads to changes in IPO underpricing in the same pattern. According to Guo *et al.* (2006), R&D (i.e., intangible assets) causes IPO underpricing because accounting assessment methods restrict R&D expenditure on financial statements. Following agency theory, Jensen and Smith (2000) demonstrated that some managers may increase their own compensation by engaging in R&D expenditure. Consequently, R&D not only can improve the future value of a company but also bring extra costs. Venture capitalists not only provide money for a startup but also bring more lasting influence on the portfolio company. According to Megginson and Weiss (1991), venture capital likely monitor the performance of firm managers to certify the true value of companies and reduce IPO underpricing. The "grandstanding hypothesis" theory proposed by Gompers (1996) suggests that VCs would like to afford the underpricing cost because the good reputation of the VC is essential in future undertakings. Lowry and Schwert (2002) indicated that a high degree of information asymmetry usually exists in technology IPOs, and this phenomenon causes a relatively huge IPO underpricing.

Using Chinese data from 30 October 2009 to 31 December 2012, Han and Shen (2017) finds that R&D information disclosure level and R&D market mispricing both have an essential influence on IPO underpricing, while venture capital functions only as a signal, not as information, hence leading to a higher degree of IPO underpricing. Using Chinese data, Zhou and Sadeghi (2019) investigate R&D spending, characterized by information asymmetry and valuation uncertainty, which can aggravate IPO underpricing. Conversely, they found a positive signal effect for patents which may significantly reduce the extent of IPO underpricing. Using Chinese firms, Peng *et al.* (2021) examine the impact of strategic customer alliances (CSA) on IPO underpricing from 2007 to 2015. Their core findings suggest that IPO firms with CSAs have less IPO underpricing than those without such a relationship.

Chin *et al.* (2006) and Guo *et al.* (2006) explored the relationship between R&D expenditure and underpricing of IPO. Megginson and Weiss (1991) investigated the relationship between venture capitalists and IPO underpricing. Jiang *et al.* (2014) examined the role of VCs in China listed companies. However, the role of technology in IPO

underpricing and the moderating influence of venture capital, R&D, and technology on underpricing of IPO have not been studied; thus, this research aims to fill this gap. Moreover, this study examines the impacts of R&D on IPO underpricing with the reciprocal effects of venture capitalists and technology. The research questions include as to whether the correlation between R&D and IPO underpricing and the correlation between technology and IPO underpricing are influenced by venture capitalists and whether technology requirement or R&D expenditure cause the interaction between R&D expenditure and technology.

On November 5, 2007, the most profitable company in Asia, PetroChina, returned to the A-share. The initial return of the company peaked at 163%, but its stock price gradually dropped after the IPO, depreciating by 76% in only over three months. As a result, a large amount of PetroChina shareholders experienced huge losses. In China's A-share market, companies in IPO (e.g., PetroChina) are common. By studying 570 A-share IPOs in China, Chan *et al.* (2004) found that the average underpricing for A-share is 178%. With respect to the venture capitals in developed countries, the venture capital in China is in the development stage, with small scale and insufficient standardization (Han and Shen, 2017). Therefore, whether China's venture capital can provide effective support and services for enterprises is unclear and deserves a detailed study. In addition, an increasing number of high-tech firms have emerged in China and helped in the country's economic growth. Thus, China's A-share market provides a good data sample for the research.

By using the cross-product residual centering methodology to study a sample of 997 China A-share IPOs in 2013–2018, we find that venture capital plays a moderating role on tech-IPO underpricing. The result illustrates that tech-IPOs experience higher underpricing. Meanwhile, although R&D expenditure does not assert influence on underpricing, it increases the underpricing rate of technology IPOs. This study also brings new insights into the existing literature, as it can demonstrate the interaction effect between technology and venture capitalists.

This study is the first one to examine the effects of venture capital backing, technology background, and R&D on IPO underpricing and the interaction relationships among them in China. Previously, Western researchers investigated the role of venture capital, R&D, and high-tech level on the underpricing of IPOs in mature stock markets. By contrast, the Chinese stock market is not mature enough. Moreover, given the government and institutional factors, the Chinese stock market will most likely show a different situation. In addition, Chinese researchers who explored the R&D and venture capital effects on IPO underpricing based on the data from China Growth Enterprise Board found considerable uncertainties on the interaction effects of technology and venture capital, R&D and venture capital, and technology and R&D on IPO underpricing; these points are explained in our study. Our research also discusses the moderating effect of venture capitalists rather than focusing only on the independent effects of the aforementioned three factors. Our results suggest that technology has a positive relationship with IPO underpricing, whereas venture capitalists tend to reduce the positive effect. Moreover, for technology IPOs, the higher is the investment in R&D expenditure, the higher is their underpricing.

The remaining part of the paper is organized as follows. Section 2 presents the literature review and the developed hypotheses. Section 3 introduces the empirical methodology and results. Section 4 discusses and analyzes the results. Our conclusion is drawn in Section 5.

## **2. Literature Review and Hypothesis Development**

### **2.1 IPO Underpricing**

In a prior study, Chin *et al.* (2006) and Guo *et al.* (2006) explore the relationship between R&D expenditure and IPO underpricing. Their result indicates that innovation capital, such as R&D spending, award patent, and patent citations, can be treated as the signals of IPO

underpricing. Companies with higher R&D expenditure experience severe underpricing. Megginson and Weiss (1991) investigate the certification role played by VCs in IPOs and find that venture-backing companies have a remarkable lower first-day return. In a study of the role of VCs in small- and medium-sized enterprise IPOs, Jiang *et al.* (2014) conclude that venture capitalists appear to have an important function in facing asymmetries of capital markets. However, no study has examined the moderating effect of VCs through the interaction of technology and R&D on the underpricing of IPOs in China's financial market.

Ibbotson (1975) demonstrates that a particular character of IPOs leads to a significant positive initial return in IPO. Ritter (1991) finds the average IPO initial return to be 14.3% for the 1526 IPOs sampled between 1975 and 1984. The method of developing information asymmetry hypotheses is the most popular approach to explain IPO underpricing. Rock (1986) suggests that information asymmetry appears between acquainted and uninformed investors. Underwriters have to underprice IPOs to hold uninformed investors. Beatty and Ritter (1986) states that the uncertainty on IPOs decides the degree of underpricing: when the unsureness is higher, the expense of accessing information is higher, and thus, the underpricing will be higher.

## **2.2 China Stock Market**

China established the Shanghai Securities Exchange (SSE) in 1990 and the Shenzhen Stock Exchange (SZSE) in 1991, the two stock exchanges in the country. Each of them serves as a main board. Unlike other countries' stock markets, the China stock market is distinct in several aspects. First, the outstanding shares have segmented ownership, which can be classified as state-owned shares, personal-owned shares, and publicly shares. Second, the China stock market is separated as A- and B-share markets. Third, the cycle between offering and listing is usually long in the China stock market. Moreover, state-owned shares account for a large proportion before and after a company goes public. These features render this study on the China stock market meaningful and unique.

China's IPO system has experienced several stages in the past three decades. From 1990 to 1995, the China Securities Regulatory Commission claimed that regulators would have to decide which company can go public at a proposed offer price under the strict IPO listing quota system. From 1995 to 2000, the China Securities Regulatory Commission required the P/E multiple of an IPO firm to not exceed 15. This restriction resulted in an extremely high over-subscription rate and huge IPO initial returns. Since 1999, the commission applied a new market-oriented system, in which the lead underwriters will initially identify a price range, then the offer price will be determined by means of individual investor transaction within the range. However, this method has caused high P/E ratios in the stock market. Since 2006, the book building approach with a "window guidance" has set the P/E multiple to an upper limit of 30. Since 2012, this approach has required an IPO firm's P/E ratio to be below 25% of the average P/E multiple of the industry peers. Thereafter, the IPO pricing system in China has formally shifted to one with a market orientation (Jiang *et al.* 2014).

## **2.3 Hypothesis Development**

### *2.3.1 Technology and IPO Underpricing*

According to Ritter (1991), the IPO underpricing phenomenon occurs in many countries. Chen *et al.* (2007) finds that the average IPO underpricing in the A-share market is 178%, which is significant. In developed capital markets, on average, IPOs are underpriced by around 15%. In emerging markets such as Malaysia, the ratio is over 80%, whereas in China, it sometimes reaches 200%, according to the China Center for Economic Research (CCER) database (Wang *et al.*, 2018). Information asymmetry is usually applied to explain the underpricing. Lowry and Schwert (2002) demonstrate that high-technology IPOs tend to have

higher underpricing because they usually take higher risk for investors. The serious underpricing in high-technology IPOs is connected with the company's future growth opportunities (Lowry and Shu, 2002). Chen *et al.* (2007) has proven the argument of Lowry and Schwert (2002) and suggest that the IPOs of high-technology firms experience higher underpricing in the Taiwan stock market than those in the other industries. On the basis of the above information, this study hypothesizes the following:

*H<sub>1</sub>: High-tech firms experience higher IPO underpricing.*

### *2.3.2 Venture Capital, Technology, and IPO Underpricing*

Venture capital is considered a widely used financial channel and well suited for the creation and business growth. According to Hellmann and Puri (2000), venture capital is used to invest in corporate equity, provide value-added service for the firm's development, and pursue high returns. Several prior studies investigate the impact of venture capital attributes on firm performance (Gompers, 1996; Gompers and Lerner, 2004; Chemmanur *et al.*, 2011). They found that four main features are widely confirmed that account for the firm-level change of investment target. These are VC investment amount, VC shareholding ratio, the VC institution's age, and the number of VC institutions involved in holding shares. According to Barry *et al.* (1990), venture capital equips a monitor function on a firm's manager as a means of certifying the portfolio's value. Megginson and Weiss (1991) demonstrate that VCs have a certification role, which increases the firm value, lessens the information asymmetry, and reduces the underpricing of IPOs. As the uncertainty about the future is high, high-technology IPOs need to undergo underpricing. However, venture capitalists can provide the assistance to decrease the uncertainty, therefore reducing the underpricing. Subsequently, we develop our second hypothesis based on the abovementioned information.

*H<sub>2</sub>: Venture capital can help to reduce the high-technology IPOs' underpricing by reducing the information asymmetry and further uncertainty associated with tech-IPOs.*

### *2.3.3 R&D and IPO Underpricing*

Aboody and Lev (2000) claim that the fundamental reason of information asymmetry is R&D expenditure. Guo *et al.* (2006) confirm the statement, arguing the R&D expenditure is the primary source of the asymmetry. By using evidence from Taiwan, Chin *et al.* (2006) support Guo *et al.* (2006) argument and show that IPOs with large R&D expenditure are underpriced higher because of the financial information asymmetry, which is a result of innovation capital standards. Therefore, we present the following hypothesis:

*H<sub>3</sub>: IPOs with higher R&D expenditure experience higher IPO underpricing.*

### *2.3.4 Venture Capital, R&D, and IPO Underpricing*

R&D is strongly related with patent count (Hausman *et al.* 1984). The patents statistic is one of the measurements that can help to decide whether R&D expenditure is effective. According to Chin *et al.* (2006), pre-IPO R&D, number of awarded patents, and patent citations are related with IPO underpricing. Although R&D brings with it asymmetry information and increases the risk faced by investors, thus reducing a firm's value, patent citations can help to increase firm value at some point. Loughran and Shive (2011) state that companies owning more granted patents usually attract venture capitalists and receive more funds, while venture capital can stimulate the innovations of companies. Gomez-Mejia *et al.* (2003) suggest that VCs play a supervisory role in monitoring the changes between the R&D expenditure and performance of firms. The level of participation of venture capitalists implies the true worth

of the R&D, which is to reduce the asymmetric information resulting from R&D. Therefore, we present the following hypothesis:

*H<sub>4</sub>: Venture capital can release the uncertainty faced by IPOs with high R&D and reduce the underpricing of such IPOs.*

### 3. Research Methodology

#### 3.1 Data Source and Sample

The data represent all IPOs in China's A-share market from SSE and SZSE for the 2013–2018 period. Our sample includes a total of 997 IPOs, excluding financial company IPOs and IPOs without integrated data. Chi and Padgett (2005) have implied the absence of significant contradictions in the underpricing degree between the two stock exchanges. The IPO data index covers company name, lead underwriter, offer price, offer date, offer size, turnover rate, industry sector, offer to first close, filing date, firm age, revenue, and R&D expense. The data were obtained using *Wind*, which is China's leading financial terminal. The data of the IPOs with venture capital investment background were acquired from the *China Venture* database. Data analysis was performed using *Stata 15.1 SE*.

#### 3.2 Measurement of Variables

This study follows the method of Lu *et al.* (2012) of measuring the dependent and independent variables to test the effects of R&D, venture capital, and technology on IPO underpricing. IPO underpricing (*MAR*) is calculated using the formula of first-day closing price minus offer price divided by the offer price.

$$MAR = \frac{P_{NH} - P_F}{P_F} \quad (1)$$

where  $P_{NH}$  denotes the first-day closing price, and  $P_F$  represents the offer price.

##### 3.2.1 Market Returns Before IPO Filing Date (*MKT*), Turnover Ratio (*TURV*), Offer Size (*PROCEED*), Underwriter Reputation (*UNDR*) and IPO Firm Age (*AGE*)

Lowry and Schwert (2002) depict investors as individuals usually concerned with IPO offer price based on public information, such as the market situation prior filing date. Following the method of Lu *et al.* (2012), we use the CSI 300 index of 30 days before filing date to represent the stock market condition before an IPO. The CSI 300 index is a component stock index compiled from 300 A-share companies selected from the Shanghai and Shenzhen stock markets. It covers approximately 60% of the market capitalization of SSE and SZSE and has good market representation.

$$MKT = \frac{I_F - I_{F-30}}{I_{F-30}} \quad (2)$$

where  $I_F$  represents the market index on filing date, and  $I_{F-30}$  is the market index 30 days before filing date.

Turnover ratio (*TURV*) is the ratio of the first-day trading volume to the total number of shares issued on the IPO day. It is the frequency at which shares change hands in the market in the first day. This variable demotes the degree of an investor's recognition of the stock value in the secondary market. On the basis of the study of Su (2004), we consider the IPO turnover rate to be controlled when examining the underpricing rate.

$$TURV = \frac{\text{The first day trading volume}}{\text{Number of outstanding shares}} \quad (3)$$

Considering that information asymmetry is not only caused by R&D, Lu *et al.* (2012) use offer size, underwriter reputation, and firm age as control variables. Offer size has been proven to be related to IPO underpricing; when the offer size is larger, the risk of asymmetric information is smaller, and the IPO underpricing is lower (Beatty and Ritter, 1986). The logarithm of IPO proceed denotes *PROCEED*. *PROCEED* equals to offer price multiply by number of shares issued.

Carter and Manaster (1990) assert that if the underwriter has a higher reputation, it can reduce information asymmetry to a certain degree. Han and Shen (2017) also use underwriter reputation as a dummy control variable to examine the R&D, venture capital, and IPO underpricing of the China Growth Enterprise Board. Following the work of Han and Shen (2017) based on the underwriter ranking of Bloomberg, we define the top 10 underwriter as underwriter reputation (*UNDR*) equals one, zero otherwise.

Prior research indicates that the longer a company is existing, the more effective the market can assess its performance, therefore decreasing information asymmetry. Following the research of Lu *et al.* (2012), we apply the logarithm of years from a firm's establishment to the IPO filing date plus 1 as a proxy variable.

### 3.2.2 Venture Capital (VC), Demand on Technology (TECH) and R&D Intensity (RD)

If an IPO is venture-backing, then venture capital (*VC*) equals one, zero otherwise. Following Lu *et al.*'s (2012) model, we use a technology industry dummy variable as a proxy. Demand on technology (*TECH*) equals one if an IPO is in the technology sector according to Bloomberg's categories, zero otherwise. Following the method of Lu *et al.* (2012) as cited in Wallin and Gilman (1986), we use the ratio of R&D expense to sales at the time before issuing to value the company's R&D. This variable is defined as

$$RD = \ln \left( 1 + \frac{RDE}{SALES} \times 100 \right) \quad (4)$$

where *SALES* and *RDE* are the sales and R&D expense of a year prior to the IPO. If the R&D and sales data a year before issuing are unavailable, then the data two years prior to issuing date are used.

### 3.3 Empirical Model

This study applies the cross-product residual centering methodology which was used by Lu *et al.* (2012) to examine the moderating effects of VCs in Taiwan's IPO underpricing. The benefit of using this methodology is the elimination of the multicollinearity phenomenon in the regression analysis model. To explore the moderating influence on the relationship between the independent and dependent variables, we use the interaction terms among the variables in the model. This lightening effect is reflected by the interaction terms. However, if a correlation exists between the main and cross-product variables, then we consider multicollinearity to often occur at this time. Therefore, applying the cross-product residual centering approach would be helpful in obtaining highly accurate results.

Regression (5) mainly examines the effect of the control variables on IPO underpricing, including market conditions, by using the CSI 300 index at 30 days before filing (*MKT*), turnover rate (*TURV*), IPO age (*AGE*), IPO proceeds (*PROCEED*), and underwriter reputation (*UNDR*).

$$MAR = \alpha_0 + \alpha_1MKT + \alpha_2TURV + \alpha_3AGE + \alpha_4PROCEED + \alpha_5UNDR + \varepsilon \quad (5)$$

In an attempt to explore the independent influences of the abovementioned three variables on underpricing, we apply regression (6) containing the moderating variables, venture capital background (*VC*), technology sector dummy (*TECH*), and R&D expenditure (*RD*).

$$MAR = \beta_0 + \beta_1MKT + \beta_2TURV + \beta_3AGE + \beta_4PROCEED + \beta_5UNDR + \beta_6VC + \beta_7TECH + \beta_8RD + v \quad (6)$$

Regression (7) introduces the interaction variable of tech-IPO and venture capitalist as a means of exploring whether the use of VC can lessen the uncertainty faced by a technology company and subsequently reduce the tech-IPO underpricing.

$$MAR = \gamma_0 + \gamma_1MKT + \gamma_2TURV + \gamma_3AGE + \gamma_4PROCEED + \gamma_5UNDR + \gamma_6VC + \gamma_7TECH + \gamma_8RD + \gamma_9VC \times TECH + \mu \quad (7)$$

Regression model (8) is used to investigate whether a venture capitalist can bring with it an inverse effect on IPO underpricing if the R&D expenditure would cause a higher underpricing.

$$MAR = \lambda_0 + \lambda_1MKT + \lambda_2TURV + \lambda_3AGE + \lambda_4PROCEED + \lambda_5UNDR + \lambda_6VC + \lambda_7TECH + \lambda_8RD + \lambda_9VC \times TECH + \lambda_{10}VC \times RD + v \quad (8)$$

Regression (9) includes all of the independent variables and interaction terms, and it is used to examine whether the demand on technology can reduce the information asymmetry led by R&D and subsequently decrease the IPO underpricing of firms with high R&D expenditures, or inversely, i.e., whether high R&D expenditure can remit the information asymmetry caused by technology and lower the tech-IPOs' underpricing.

$$MAR = \theta_0 + \theta_1MKT + \theta_2TURV + \theta_3AGE + \theta_4PROCEED + \theta_5UNDR + \theta_6VC + \theta_7TECH + \theta_8RD + \theta_9VC \times TECH + \theta_{10}VC \times RD + \theta_{11}TECH \times RD + \omega \quad (9)$$

## 4. Empirical Results

### 4.1 Descriptive Statistics and Correlation

Table 1 presents the descriptive statistics for all of the variables. Column 1 of Table 1 lists the dependent and independent variables. The average IPO underpricing in China is 43.9%, which is significantly higher by 10%–20% than the IPO underpricing level in mature capital markets. The average turnover rate is at a low value of 0.7%, indicating that the speculation phenomenon is not obvious in this sample stock market. The rational investment greatly reduces the IPO underpricing. The minimum IPO proceed is 78.3 million RMB, whereas the maximum proceed is 27120.41 million. The difference is large, which implies that the IPO scale is noticeably different from those in China's mainboard stock market. This fact may be explained as the A-share market covering all of types of industries, and industry differences are usually huge. The same reason can also explain the difference between firm age, as the industries and development stages of the listed companies on the mainboard market are scattered and not concentrated.



**Table 1:** Descriptive statistics for the independent variables used in the multiple linear regressions

Variable	Mean	Std. Dev.	Min	Max
<i>MAR</i>	0.439	0.014	0.136	0.460
<i>MKT</i>	-0.017	0.058	-0.202	0.260
<i>TURV</i>	0.007	0.050	0.000	0.844
<i>PROCEED</i> (in mil RMB¥)	577.975	1095.704	78.300	27120.430
<i>UNDR</i>	0.493	0.500	0	1
<i>AGE</i> (in year)	14.226	5.459	3	55
<i>VC</i>	0.573	0.495	0	1
<i>TECH</i>	0.220	0.414	0	1
<i>RD</i>	1.609	0.595	0.000	3.661
<i>N</i>	997	997	997	997

Table 2 shows the correlation among the variables. Turnover rate is significantly and negatively related with underpricing. The IPOs with a higher turnover rate are less underpriced ( $TURV = -0.049$ ). An underwriter with good reputation brings more proceed for IPOs. Firm age can be treated as a factor reflecting IPO underpricing; that is, an older company usually has a higher underpricing level ( $AGE = 0.067$ ). In addition, VC-backing IPOs experience lower underpricing ( $VC = -0.114$ ), suggesting that venture capital can help to reduce the underpricing phenomenon. Following Lewis *et al.* (2003), a simple bivariate correlation is used in this study to determine the existence of relationships between two different variables, such as tech-IPO and non-tech IPO. It shows how much tech-IPO will change when there is a change in non-tech IPO. We find that Tech-IPOs have higher underpricing compared with non-tech-IPOs ( $TECH = 0.083$ ). The technology industry often represents a high-risk industry, a scenario that explains why investors are more confident with non-tech-IPOs and prefer low-risk IPOs.

**Table 2:** Correlations for the independent variables used in the multiple linear regressions

Variables	<i>MAR</i>	<i>MKT</i>	<i>TURV</i>	<i>PROCEED</i>	<i>UNDR</i>	<i>AGE</i>	<i>VC</i>	<i>TECH</i>	<i>RD</i>
<i>MAR</i>	1								
<i>MKT</i>	-0.033	1							
<i>TURV</i>	-0.469***	0.110***	1						
<i>PROCEED</i>	-0.112***	0.028	0.042	1					
<i>UNDR</i>	-0.005	-0.017	-0.033	0.129***	1				
<i>AGE</i>	0.067**	0.039	-0.082***	-0.085***	-0.075**	1			
<i>VC</i>	-0.114**	0.065**	0.018	0.016	-0.023	-0.052*	1		
<i>TECH</i>	0.083***	-0.017	-0.037	0.018	0.048	-0.082***	0.047	1	
<i>RD</i>	0.042	0.000	-0.032	-0.108***	0.020	-0.026	0.055*	1	1

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Table 2 also shows that underwriter reputation is higher in younger firms than that in older firms ( $AGE/UNDR = -0.075$ ). Companies with venture capital background and belong to the high-tech industry are younger firms. Venture-backing IPOs provide higher R&D ( $RD/VC = 0.055$ ), verifying that venture capitalists prefer to invest in companies with high R&D. R&D also has a significant positive relationship with technology ( $RD/TECH = 0.381$ ), which is common in the technology industry. High-tech companies have to invest more money in R&D compared with non-tech companies.

## 4.2 Main Results

After conducting the moderating regression model, we obtain the empirical result. This Table 3 combines five regression models, as previously demonstrated, and investigates the effects of the control variables, VC background, technology requirement, and R&D expenditure on IPO underpricing and their interaction terms.

**Table 3:** Results of moderating linear regression between IPO underpricing and the independent variables

Variables	(1)	(2)	(3)	(4)	(5)
<i>MKT</i>	0.006 (0.937)	0.007 (1.050)	0.007 (0.976)	0.007 (0.971)	0.007 (0.970)
<i>TURV</i>	-0.126*** (-16.361)	-0.126*** (-16.192)	-0.126*** (-16.199)	-0.126*** (-16.205)	-0.126*** (-16.198)
<i>LAGE</i>	0.002 (1.407)	0.002 (1.376)	0.002 (1.414)	0.002 (1.371)	0.002 (1.377)
<i>PROCEED</i>	-0.002*** (-2.959)	-0.002*** (-2.849)	-0.002*** (-2.943)	-0.002*** (-2.931)	-0.002*** (-2.934)
<i>UNDR</i>	-0.000 (-0.076)	-0.000 (-0.098)	-0.000 (-0.083)	-0.000 (-0.045)	-0.000 (-0.059)
<i>VC</i>		-0.003*** (-3.960)	-0.002** (-2.454)	-0.004* (-1.657)	-0.004 (-1.634)
<i>TECH</i>		0.003** (2.527)	0.005*** (3.395)	0.006*** (3.474)	0.005 (1.385)
<i>RD</i>		-0.000 (-0.355)	-0.000 (-0.443)	-0.001 (-0.860)	-0.001 (-0.871)
<i>VC × TECH</i>			-0.004** (-2.298)	-0.005** (-2.416)	-0.005** (-2.408)
<i>VC × RD</i>				0.001 (0.764)	0.001 (0.746)
<i>TECH × RD</i>					0.000 (0.168)
<i>Prob&gt;F</i>	0.0000	0.0000	0.0000	0.0000	0.0000
<i>Obs.</i>	997	997	997	997	997
<i>Adj-R<sup>2</sup></i>	22.99%	23.99%	24.32%	24.28%	24.21%

Notes: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. T-values are in parentheses. *LAGE* is defined as the logarithm of the firm age from startup to going public plus 1. The interaction terms are the products of two independent variables.

Table 3 presents the effect of technology, R&D, and VC dummy on IPO underpricing and their cross-product terms. The control variables include market index, shares turnover ratio, firm age, IPO proceed, and underwriter reputation. The coefficient associated with *TURV* variable (-0.126) is negative and significant ( $P < 0.01$ ,  $t = -16.361$ ) in column 1 of Table 3. This reveals that the turnover ratio is negatively correlated with IPO underpricing, which means that the higher is the turnover ratio, the lower is the underpricing rate. This finding was unexpected and implies that when new shares are traded more frequently on the secondary market, the closer the first day's closing price is to the offer price, and the lower the underpricing rate. The coefficient associated with *PROCEED* variable (-0.002) is also negative and significant ( $P < 0.01$ ,  $t = -2.959$ ) in column 1 with underpricing. This result suggests that when the offer size is larger, the effect of information asymmetry is smaller, and the lower is the underpricing.

The coefficient associated with *VC* variable (-0.003) is negative and significant ( $P < 0.01$ ,  $t = -3.960$ ) in column 2 of Table 3. This result indicates that a venture capitalist can cut down the IPO underpricing. The coefficient associated with *TECH* (-0.005) is positive and significant ( $P < 0.01$ ,  $t = 3.395$ ). This finding suggest that the technology company has a higher underpricing because such type of firm has to take more risk that what is common in the technology industry. This result confirms hypothesis 1.

However, *RD* is not significant with IPO underpricing ( $t = -0.355$ ), which rejects hypothesis 3. During the data collection process, we used the R&D and sales figure from one year before the issuing date for the IPOs in 2013–2016. The R&D and sales number at one year before issuing date for the 2017 and 2018 IPOs were unavailable. Thus, we calculated *RD* by using two years before IPO date for the R&D and sales of the 2017 and 2018 IPOs.

The interaction term  $VC \times TECH$  was added in the third model. The result is presented in Column 3 of Table 3. The tech-IPO experiences a much greater underpricing ( $t = 2.527$ ). The  $VC \times TECH$  variable has a significant negative relationship ( $t = -2.298$ ) with the dependent variables, which demonstrates that VC has a moderated effect on tech-IPO underpricing, reducing the uncertainty faced by technology companies. This fact verifies hypothesis 2. Column 4 of Table 3 indicates that the cross-term  $VC \times RD$  ( $t = 0.764$ ) is not significant, which means that venture capital has no direct moderating effect on the relationship of R&D expense and IPO underpricing. Hypothesis 4 regarding the VC and R&D does not appear to be well grounded. Column 5 of Table 3 shows that  $TECH \times RD$  ( $t = 0.168$ ) is not significant with underpricing. Thus, RD does not have the moderating effect on the relationship of technology firms and IPO underpricing.

According to the above analysis, R&D expenditure does not have a significant influence on the underpricing of IPOs in China's A-share market. Subsequently, we further develop the sub-group analysis by examining the relationship of R&D and IPO underpricing in the technology and non-technology sectors. Table 4 presents the effect of technology on the relationship of R&D and IPO underpricing. The control variables are market condition, turnover rate, age of IPO firms, IPO proceeds, underwriter reputation, venture capital dummy, and RD intensity. Column 1 of Table 4 lists the tech-IPOs, in which R&D has a significant negative relationship at  $t = -2.313$ . However, R&D does not have any effect of non-technology IPOs with respect to the underpricing ( $t = -0.671$ ). Therefore, the greater is the R&D expenditure, the smaller is the degree of underpricing in the technology industry. For the high-tech companies, the disclosure of R&D expenditure will affect the judgement of investors.

**Table 4:** Sub-analysis of the effect of technology on the relationship between R&D spending and IPO underpricing

Variables	<i>TECH</i>	<i>NON-TECH</i>
<i>MKT</i>	-0.001 (-0.840)	0.006 (0.712)
<i>TURV</i>	0.087*** (20.652)	-0.128*** (-14.635)
<i>LAGE</i>	-0.000 (-0.702)	0.002* (1.679)
<i>PROCEED</i>	-0.000 (-1.163)	-0.002*** (-3.074)
<i>UNDR</i>	-0.000 (-0.089)	-0.000 (-0.180)
<i>VC</i>	-0.000** (-2.087)	-0.000 (-0.097)
<i>RD</i>	-0.000** (-2.313)	-0.001 (-0.671)
<i>Prob&gt;F</i>	0.0000	0.0000
<i>Obs.</i>	219	778
<i>Adj-R<sup>2</sup></i>	66.64	23.94

Notes: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ . T-values are in parentheses. *LAGE* is defined as the logarithm of the firm age from startup to going public plus 1. The interaction terms are the products of two independent variables.

Overall, after examining the five regression models, we can demonstrate on the basis of Table 3 that the turnover rate has very significant relatively with underpricing ( $t = -16.361$ ). Popular new stock trading in the secondary market can help to reduce the information asymmetry, therefore considerably lessening the underpricing of the IPOs. Table 3 also shows that proceed has a negative relationship with underpricing ( $t = -2.959$ ), implying that the large

scale of IPOs will reduce the underpricing degree. Column 2 of Table 3 suggests that venture capitalists can help to release the IPO underpricing, thus confirming the hypothesis 1. The second model similarly highlights that tendency of technology to facilitate IPO underpricing. Column 3 of Table 3 shows that venture capitalists can bring with it a moderated effect on the IPOs in the technology industry. The  $VC \times TECH$  variable is negatively significant at  $t = -2.298$ , given that  $TECH$  is positively significant ( $t = 3.395$ ). Columns 4 and 5 of Table 3 illustrate that R&D expenditure does not affect IPO underpricing. The R&D effect on the technology-underpricing relationship is analyzed accordingly. The result shown in Table 4 conveys that a greater R&D expenditure can decrease the underpricing in the technology sector ( $t = -2.313$ ).

## 5. Discussion

Our research objective is to investigate the moderating effect of VCs through the interaction of technology and R&D on the underpricing of IPO in China's A-share market. The detailed research questions attempt to explore as to whether technology firms experience much higher IPO underpricing and whether venture capital can help to reduce the underpricing effect on tech-IPOs. Then, we test whether high R&D intensity IPO experience higher IPO underpricing and whether venture capital can help lessen the effect. For the result, this study expects that tech-IPOs and high R&D IPOs will experience much higher underpricing. Moreover, the study predicts that the use of venture capital will alleviate the IPO underpricing caused by technology and venture capital can reduce the uncertainty faced by high-R&D IPOs, subsequently reducing the underpricing. The actual result thoroughly confirms hypothesis 1. Interestingly, the result we obtained concerning the second hypothesis was unexpected. R&D does not have any correlation with IPO underpricing based on the regression model result. However, on the basis of the sub-analysis, we propose that R&D has a significant correlation with underpricing for technology companies. Griliches (1998) commented that a company's R&D expenditure level is positively correlated with the company's future value. For high-tech companies, such an influence is more obvious than that in non-tech firms. The evaluation of R&D expenditure efficiency needs to be analyzed in conjunction with the industry's competitive environment, operating conditions, and national industrial policies. However, most investors do not have the professional knowledge and the information research ability. Thus, an increase in R&D expenditure will increase the level of information asymmetry between the issuer and the investors.

Although our result regarding R&D and IPO underpricing differ from those of Lu *et al.* (2012) and Han and Shen (2017), it can be argued from several points. Fu *et al.* (2011) explored whether R&D investment level affects IPO underpricing, as with Chen *et al.* (2007); both studies selected the IPOs of growth enterprise market (GEM) as their samples. By contrast, we selected the companies listed in the mainboard of the China stock market. Fu *et al.* (2011) claimed that the mainboard listed companies generally include R&D investment in management expenses and rarely offer separate disclosures or incomplete disclosures. Second, industry and company size have a significant impact on the company's R&D expenditure. The mainboard listed companies have relatively fragmented industries, whereas the GEM listed companies have similar sizes and concentrated industries. Therefore, the A-share mainboard IPO sampling increases the error caused by the difference in industry and company size.

With respect to the other previous studies, our study has generated consistent results and also contradicting aspects. First, Lu *et al.* (2012) suggested that IPOs with technology have a greater degree of underpricing, and the emergence of venture capitalist can moderate the positive correlation between underpricing and high technology in the Taiwan stock market. This finding is consistent with our result. Second, Han and Shen (2017) commented that their

empirical result does not support the expectation that venture capital has an adjustment relationship between R&D investment and IPO underpricing. A reasonable explanation would be that the level of venture capital involvement in GEM is not high enough. Third, in the study on R&D and IPO underpricing in GEM, Fu *et al.* (2011) stated that R&D investment level is positively related to IPO underpricing. This point validates that as the R&D expense increases, the information asymmetry between issuers and investors will significantly improve. Our conclusion is inconsistent with this result concerning R&D.

It is plausible that a number of limitations may have influenced the obtained result. To begin with, we selected China's A-share mainboard IPOs as our sample. As most of the companies in the mainboard are already mature enough, the influence of R&D and venture capital may not be huge. Second, we did not add the company's return on equity and capital structure as the control variables, which are related with the valuation of the company from investors. Additionally, for the VC variable, we did not include VC-equity stakes, venture capitals' size, and reputation index; we only considered the presence of venture capital. Data collection is further required to determine exactly the relationship between venture capital and IPO underpricing. Another possible source of error is we did not consider the effect of market fluctuation on IPO underpricing when we designed the model, and we did not use the adjusted underpricing rate.

### 5.1 Reliability and Validity

Apart from the slight discrepancy, given the research method and the sample collection technique, our research remains to be reliable and valid. First, the following evidence proves the internal validity: Lu and Chen (2012) confirmed the relationship among venture capital, technology, and R&D expenditure with IPO underpricing in the Taiwan stock market. We applied a similar model in our research and adjusted the model by considering the special situations in the China stock market. The adjustments were based on Han and Shen's (2017) empirical study on R&D, venture capital, and IPO underpricing from GEM IPOs.

Second, the external validity can be demonstrated as follows. The sample of our study covers 2013–2018 and all of China's A-share IPOs, excluding the finance companies. The sample size consisted of 997 IPOs, which was larger than the sample size in the existing similar studies. All of the data were mainly collected from Wind, which is China's leading financial terminal. This fact can guarantee the accuracy of the collected data. In summary, our research model can fit most capital market types at some point, and our study is reliable.

Third, we analyzed the variance inflation factor statistics and examined the multicollinearity among variables. Excluding the interaction terms, the mean VIF is 1.045, which is below 10. After adding VC, TECH, and RD, the mean VIF is 1.089 and remains below 10. This result confirms that multicollinearity does not exist in our model, and our finding is substantial.

**Table 5:** Variance inflation factor for the control variables and all variables

Variables	Control variables only		All variables	
	VIF	1/VIF	VIF	1/VIF
<i>MKT</i>	1.019	0.981	1.024	0.977
<i>TURV</i>	1.035	0.966	1.037	0.964
<i>LAGE</i>	1.023	0.978	1.036	0.966
<i>PROCEED</i>	1.082	0.924	1.126	0.888
<i>UNDR</i>	1.066	0.938	1.072	0.932
<i>VC</i>			1.013	0.987
<i>RD</i>			1.217	0.822
<i>TECH</i>			1.184	0.845
<i>Mean VIF</i>	1.045	.	1.089	.

## 5.2 Theoretical Contribution

Numerous studies have examined the roles of venture capital, technology, or R&D on IPO underpricing, but most of the samples had been on the Western stock market, such as those of Italy and Germany. Meanwhile, a number of published Chinese papers have explored the effects of R&D and venture capital on IPO underpricing based on the data from the China Growth Enterprise Board. Our research focuses on all IPOs from China's A-share market, indicating an expanded sample size. More importantly, this study offers new insights by illustrating the interaction effect between R&D and technology on IPO underpricing as a means of explaining the moderation influence of venture capitalists on IPO underpricing.

## 6. Conclusion

The most popular theory to explain IPO underpricing is the uncertain future value and information asymmetry. Technology companies have the characteristics of high risk and high return, which brings the uncertainty to the companies' future value. The intervention of venture capital is a good approach to reduce information asymmetry. The China IPO market grows rapidly, which provides a good data sample for exploring the relationship among venture capital, R&D, and technology on IPO underpricing. This study uses the cross-product residual centering approach to build the regression model, in which market condition, offer size, firm age, underwriter reputation, and IPO turnover rate are included as the control variables. Then, the products of VC and TECH, VC and RD, and TECH and RD are added as the interaction variables. The evidence from this study suggests that tech-IPOs experience much higher underpricing, while R&D expenditure does not assert influence on the underpricing, which may contribute to the possibility of having different R&D disclosure levels in the mainboard market, but R&D will increase the underpricing rate for technology IPOs. Moreover, this study contributes new insights by illustrating the interaction effect between technology and venture capitalist and by explaining the moderation influence of venture capitalist on IPO underpricing. For the finance market, the result indicates that if a company had venture capital investment before listing, the risk associated with operation or finance will be less. Also, in order to reduce IPO underpricing, financial regulator should try to reduce the information asymmetry that between public and companies. However, this study does not explore the same relationship in China's stock GEM and small- and medium-sized enterprise board, and our model design does not consider the influence of capital market fluctuations on IPO underpricing. Further research is needed to study the different stock market boards in China, apply the market-adjusted IPO underpricing, and consider the venture capitals' share percentage of IPO companies and venture capital reputation in the research model.

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