# Security Supply and Bubbles:

# A Natural Experiment from the Chinese Warrants Market [1]


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## ABSTRACT

Consistent with theory prediction and experimental findings, the availability of short-sale-like security supply mechanism is helpful to mitigate bubble formation in the warrants market in China. We document that the frequency and degree of bubble (excessive over-pricing) for warrants listed at the Shanghai Stock Exchange, where additional warrants issuance (short-sale-like mechanism) is practiced, are considerably lower than those for warrants listed at the Shenzhen Stock Exchange, where additional warrants issuance is not practiced. For warrants that experienced new issuance, pricing premiums become significantly smaller. Additional warrant supply, however, cannot completely remove bubbles. Our results provide important field evidence in support of extant experimental results that short sales can reduce bubbles.

The formation and escalation of bubbles in financial markets has long been a puzzling phenomenon to scholars in the field of economics and finance. Historical bubbles such as the tulip mania and the south sea bubble caused tremendous turmoil in the capital markets in their infancies (Kindleberger, Aliber and Solow (2005)). During the past several decades, the occurrences of the bubbles in the Japanese real estate market, in the internet and technology companies, and in the U.S. real estate market, seem to suggest that people still lack understanding about some of the very basic features of the formation of bubbles or measures that are necessary to prevent or alleviate bubbles.

Several theoretical studies point out that the lack of short sales is potentially responsible for the bubbles in financial markets. For example, Allen, Morris and Postlewaite (1993) Scheinkman and Xiong (2003) and Hong, Scheinkman and Xiong (2006), all show with their theoretical models that short sales constraint, or the lack of short sales practice, is directly linked to the formation and escalation of bubbles. Several experimental studies provide support that short sales help reduce bubbles. For example, Porter and Vernon (1995), Haruvy and Noussair (2006), and Lei, Noussair and Plott (2001) show that relaxing short-sale constraints can considerably reduce asset bubbles in the setting of laboratory experiments.

However, empirical evidence regarding the effectiveness of short sales in removing bubbles remains limited and mixed. On one hand, many empirical studies suggest that the lack of short sales is directly related to security over-pricing and future negative abnormal returns (Jones and Lamont (2002), Ofek, Richardson and Whitelaw (2004), Danielsen and Sorescu (2001)). On the other hand, however, Bris, Goetzmann and Zhu (2007) study the practice of short sales in

global financial markets and fail to find that short sales help prevent extreme negative returns at the market level or prevent market from crashing.

Several obstacles seem to hinder empirical research on bubbles. First, most of the bubbles can only be identified ex-post, as opposed to ex-ante, making it difficult to identify investors' concurrent expectation and belief. In addition, because the fundamental values of many securities are difficult to determine, it is often not straightforward to assess the extent of bubbles even afterwards. Further, changes in short sales regulations can sometimes be endogenous and due to abrupt changes in market conditions, it is not straightforward to interpret their impact of reducing bubbles or preventing crisis is (Beber and Pagano (2009) , Bris, Goetzmann and Zhu (2004)).

The current study intends to bridge such a gap in the literature by studying bubbles in the warrants market in China. The newly introduced warrants market in China provides a unique setting to investigate bubbles and short sales.[2] Unlike many other securities whose fundamental values are difficult to determine, it is relatively straightforward to estimate the fundamental values of many warrant contracts, due to the price movement limit in the Chinese stock market. As a matter of fact, Xiong and Yu (2009) and Pan, Shi and Song (2008) document that, it is common that investors trade warrants that are severely over-priced or intrinsically worthless, sometimes even with higher-than-average volumes. Xiong and Yu (2009) attribute such trading activities to the option value of speculative bubbles and take such phenomenon as support of the theory of the greater fool: investors purchase warrants with the expectation of re-selling them to other investors at higher prices.

[2] There were some incidences of warrant trading during the very early days of Chinese stock market, particularly around periods of stock issuance, during the 1992-1996 periods.

Another unique feature of the Chinese warrants market is that new warrants can be issued after initial issuance for some warrants but not others. Because there was no practice of short sales in the Chinese stock market, transacting warrant contracts provides one way for investors to express their bearish views. Further, the issuances of additional warrant contracts can provide additional supply of securities and act as a potential way to sell the market short by brokerage firms that originate such warrants. Thus, the Chinese warrants market provides an interesting setting in which there are identifiable bubbles, and variations in the practice of short sales. By studying the differences in pricing properties of warrants listed at the Shanghai Stock Exchange, where additional warrants were issued, and those listed at the Shenzhen Stock Exchange, where no additional warrant was issued, we empirically gain new insights into the impact of security supply, a corner stone to short sales, on the formation and escalation of bubbles in financial markets.

Our empirical analysis shows that, consistent with Xiong and Yu (2009), many warrants trade at prices that are considerably higher than their fundamental values, hence constituting bubbles in the market. As a matter of fact, many warrants trade for positive prices even though their intrinsic value is zero. Interestingly, we find patterns consistent with theory prediction and extant experimental evidence that short sales can reduce the occurrence and extent of bubbles. First and foremost, warrants that experienced additional issuance, which provides additional securities to the market and offers brokerage firms and investors more shares to sell against the securities, deviate from their fundamental values far less often. For example, for warrants with theory price in the range of 0.1 and 1 Yuan, in which the largest proportion of warrants is observed, those warrants with new issuance deviate from their fundamental values by 0.5 Yuan

or more for 40.8 percent of time. The occurrence of such considerable deviation is far more often at 60.8 percent, for warrants that did not experience additional issuance.[3]

Secondly, for trading days when warrants deviate from their intrinsic values, the deviation is much smaller for warrants with new issuance than those without new issuance. For example, for all six categories of warrants classified by different levels of fundamental values, the absolute dollar value of over-pricing is highly significantly smaller for warrants that experienced new issuance. As a matter of fact, the average premium in dollar is 0.60 Yuan (101.26 percent) greater for the non-issuance group than for the group of warrants with new issuance. To alleviate potential confounding effect from the absolute level of warrant fundamental values, we also estimate the difference in over-pricing measured in percentage. For the four categories of warrants with fundamental values that are meaningful for comparison (warrants whose fundamental value is greater than or equal to 0.001 Yuan), the percentage deviation is again considerably larger for the non-issuance group than for the issuance group for all classifications based on warrants' fundamental values.

Further, our difference-in-difference analysis around the introduction of additional warrants depicts a clear picture about the causality of the relationship. We find that the degree of over-pricing is much lower after the introduction of additional warrants. For example, the average dollar premium decreased from 0.88 Yuan for the five-day-window immediately before- to 0.76 Yuan for the five-day-window immediately after- the maximum cumulative introduction

[3] There are some weak indications that the same warrants were less likely to be traded at price levels that are 0.5 Yuan higher than their fundamental value, after additional warrant issuance. Such evidence is, however, statistically insignificant, partly because most additional warrant issuance took place right after original warrant issuance, which limits the sample size for comparison.

of additional warrants.[4] When comparing the degree of over-pricing before and after warrant introduction for each individual put warrant, we find that, after the maximum cumulative introduction of additional warrants, three warrants experienced significant decrease in the degree of over-pricing, no warrant experienced significant increase in the degree of over-pricing, and the remaining seven warrants experienced no significant changes. Additional exercises that examine different length of event windows and additional exercises that examine both call and put warrants with additional issuance generate consistent results.

Our study makes the following three primary contributions to the literature. First, we are among the first to provide field evidence that supply of securities, a necessary condition for short sales, can reduce the occurrence and extent of bubbles. Extant studies (Haruvy and Noussair (2006), Ackert, Charupat, Church and Deaves (2006)) using laboratory experiments show that the introduction and practice of short sales can reduce the severity of bubbles in laboratory markets. According to several empirical studies, such a phenomenon may be caused by the fact that short sales can facilitate negative information dissemination. For example, Jones and Lamont (2002), Danielsen and Sorescu (2001), and Ofek, Richardson and Whitelaw (2004) show that the availability of shares to sell and the ease of short sales both matter. With additional shares available to sell, investors with negative opinions can communicate their negative information through additional selling and cause security prices to fall. Our study synthesizes the spirits from both strands of research and shows empirically that additional security supply, which can facilitate and work out like short sales, is effective in dampening security prices and reducing bubbles.

[4] The difference is significant at the 10 percent level, due to the relatively small sample size.

In addition, our study provides new evidence regarding whether short sales can eliminate bubbles. Extant experimental studies report mixed findings. For example, Davies (2006) shows that shares can trade at discount, instead of premiums, to their fundamental values, with the presence of short sales practice and with increases in securities' intrinsic values in laboratory experiments. In contrast, several other studies (Haruvy, Yaron and Noussair (2007), Noussair, Stephane and Bernard (2001)) report that bubbles seem to persist, albeit to a far less extent, in market environment with the practice of short sales. Understanding short sales' effectiveness in preventing or removing bubbles is not only important for making key assumptions in theoretical studies (Allen, Morris and Postlewaite (1993), Hong, Scheinkman and Xiong (2006)), but also essential for policy makers and regulators to design and modify short-sales-related policies. Our results from the field seem to suggest that although the lack of available shares for selling or short selling is clearly responsible for the formation of bubbles, the lack of short sales is not the sole driver behind bubbles and the practice of short sales may not be able to solve the entire problem of bubbles entirely.

Finally, our results help resolve the controversy regarding the impact of short sales. It is widely accepted that an important component of short sales is that it introduces difference of opinion into the market (Miller (1977), Jones and Lamont (2002)) and such revelation of different opinions helps facilitate information flow and price discovery. As the market becomes more informational-efficient, security prices are less likely to deviate away from their fundamental values. As a result, bubbles are less likely to happen. On the other hand, some other studies (Macey, Mitchell and Netter (1988), Morris and Shin (1998)) contend that short sales may cause self-fulfilling prophecy and aggravate security price plummeting. Especially after the

recent financial crisis, more people argue that short sales should be held responsible for the market slump during the crisis and therefore should be constrained.

One interesting feature of the Chinese warrants market is that there is no change in terms of the short sales constraint. Unlike the practice of short sales in many western markets, where the same investors create additional shares to short sell and actually short sell the securities, the issuers and sellers of the same securities are separate in the Chinese warrants market. The brokerage firms, which issue additional shares, do not actively trade in the market after issuing the warrants.[5] The warrant investors, who keep buying and selling the securities, cannot obtain additional shares to sell except with the additional issuances from the brokerage companies. Our evidence show that, even without the coordination of the borrowing and short selling activities by the same type of investors, which may be motivated by the investors' intention to profit from maliciously driving down security prices, the additional supply of securities to the market can still effectively attenuate bubbles. Therefore, our findings suggest that additional security supply by a third party may be introduced as an alternative way to reduce bubbles without disrupting the market.

The rest of the paper is organized as follows: Section 2 provides an overview of the newly introduced warrants market in China and the unique background it provides to study bubbles and short sales; Section 3 discusses the data employed in the empirical study; Section 4 proposes testable hypothesis and research methodology; Section 5 presents empirical findings and discusses our results, before we conclude in Section 6.

[5] According to Shanghai Stock Exchange's regulation on warrants, warrant issuers cannot transact on the warrants that they issue.

## Section 2. The Chinese Warrants Market: A Natural Experiment for Bubbles and Short Sales

### 2.1. The Chinese Stock Warrants Market: Example of Speculative Bubbles

The China Securities Regulatory Commission (CSRC) introduced a small number of warrants starting trading in August 2005 as an initial step to open up the financial derivatives markets and provide more investment vehicles to the Chinese securities markets. In some sense, stock warrants are considered as close substitutes to stock options issued by publicly listed firms in China and the broader Asian financial markets.[6]

There are two basic types of warrants being issued and transacted. A call warrant gives its holder the right to buy a stock from the issuing firm at a predetermined strike price during a pre-specified exercise period, whereas a put warrant gives its holder the right to sell a stock back to the issuing firm. Both call and put warrants derive their values from the underlying stock prices: the value of a call warrant increases with the stock price, whereas that of a put warrant decreases. By June 2010, 18 put warrants and 37 call warrants had been issued to the public. Among them, 39 were traded in the Shanghai Stock Exchange and 16 in the Shenzhen Stock Exchange.

Several features of the Chinese warrants market distinguish it from the Chinese stock market. First, unlike stock trading which is subject to the so called "T+1" rule, which requires investors to hold their stocks for at least one day before selling, warrants trading is subject to the "T+0" rule, which allows investors to sell warrants they purchased earlier on the same day.

[6] Similar to the practice in Hong Kong and Taiwan, the warrants in China can be issued by both the listed companies and brokerage firms.

According to the CSRC, this is intended to help investors take better advantages of financial derivatives for hedging and speculation purposes. At the same time, some market participants conjectured that such a regime shift in the regulation was also intended to improve market liquidity, during the market downturn in 2002-2005. As a result, investors can pursue day-trading strategies in warrants but not in stocks.

Second, investors incur lower transaction costs in warrant trading. In China, investors trading stocks typically pay stamp tax to the government and commissions to brokerage firms for both sides of a round-trip transaction[7]. The stamp tax is determined by a flat percentage of the total proceeds. The tax rate has changed several times in the past, ranging from 0.1% to 0.3%. The trading commission is negotiable between the investors and brokers and is capped at 0.3% of the total proceeds.

In contrast, investors trading warrants are exempted from paying any stamp tax. They still need pay commissions to brokerage firms, which is also negotiable and is capped at 0.3% of the total proceeds. In addition, Because of the large volume in the warrants market, brokers usually charge a lower trading commission on warrants than on stocks. It is worth noting that, in addition to the 0.3% commission cap, there is also a 5 RMB Yuan floor for trading commission for any transaction.[8] As a result of such a floor requirement and the relative smaller amount

[7] The stamp tax was lowered to be levied on one way of the transaction, in the wake of market downturn of 2008-2009.

[8] In addition, investors also have to pay handling fee worth of 0.004% of their transaction value to CSRC and handling fee of 0.0045% to the respective stock exchanges. Between August 22, 2005 and August 21, 2008, investors are exempt from paying 50% of handling fee in the Shanghai Stock Exchange.

being invested in stock warrants, many investors ended up paying a higher percentage commission than they do when trading common equities.[9]

Third, the difference in the sizes of daily price change limit allows a wider range of price movement for warrants than for stocks. The CSRC imposes a 10% limit on daily price change of most stocks traded on the two stock exchanges.[10] If the rise or fall of a stock price reaches 10% in comparison with the previous day's closing price, the stock price is not allowed to move beyond that limit. With the large volatility in the Chinese stock market, individual stocks often hit their daily price change limit.[11] On the other hand, the daily permissible price change of a warrant is equal to the product of daily permissible price change limit of the underlying stock in Yuan, the warrant's conversion ratio, and a factor of 1.25. This essentially makes the size of daily permissible percentage price change of warrants much larger. As a result, warrants do not often hit their daily price change limit despite their dramatic price movements.

2.2. The Warrant Origination Mechanism: Additional Warrant Issuance

Shortly after the introduction of the first warrant, BaoSteel's call warrant (ticker name 580000.SH), on August 22, 2005, it becomes clear to the market that the newly introduced warrants have become the center of market speculation. On the second day after its introduction, the trading volume of BaoSteel's call warrant became so big that it claimed 14 percent of combined trading volume at the Shanghai and Shenzhen Stock Exchange.

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[9] Please see Liao et al. (2010) for greater details.

[10] A number of stocks under special treatment (ST stocks) are traded with a 5% daily price change limit.

[11] According to the Shanghai Stock Exchange, A-share stocks (excluding ST stocks) reach their daily price movement limit for 1.92 percent of all trading days in the period of 2000-2005.

Within three months of its introduction, BaoSteel's call warrant has often been trading at price levels that are at least 50 percent greater than its implied fundamental value. Partly to cool off the burgeoning speculation and keep market order, the Shanghai Stock Exchange introduced the warrant origination mechanism at WuSteel's call warrant (ticker name 580001.SH) and WuSteel's put warrant (ticker name 580999.SH) on November 28, 2005.

The regulation stipulates that qualified brokerage firms[12] can originate (issue) additional warrants if the brokerage firms deposit enough shares (for call warrants) or enough cash (for put warrants) for the exercising of such warrants upon the maturity time and if the brokerage firms' application for originating additional shares is approved by the Shanghai Stock Exchange.

Several features of the requirement are worth discussing. First, once upon approval, the brokerage firm can originate additional warrants which are typically available to trading the next trading day.[13] Such a requirement facilitates speedy introduction of additional warrants if brokerage firms deem the securities "overpriced" and it is lucrative to sell such warrants to the investor community. Second, the brokerage firms that originate additional warrants also have the option, subject to approval by the Shanghai Stock Exchange, to buy back the additional warrants originated by the same brokerage firm. Such a requirement provides brokerage firms the flexibility of reversing their warrant origination and encourages brokerage firms to engage in warrant origination. Finally, upon warrant maturity, the brokerage firms are obligated to honor warrant exercise before the listed company of the underlying stocks of warrants. Such a

[12] "Qualified" brokerage firms are typically those brokerage firms that generate more revenues, profits, and enjoy better credit soundness. 13 out of 116 brokerage firms were classified as "qualified" at the time of warrant introduction. 29 out of 106 brokerage firms were classified as "qualified" after August 2007.

[13] There were rare incidents that the additional warrants commence trading on the same day after their origination.

requirement ensures that the original issuers of the warrants (listed companies or brokerage firms) are "protected" from malicious origination of warrants that may impair the listed company's interest.

The Shenzhen Stock Exchange introduced a similar stipulation ten days after the introduction of the stipulation at the Shanghai Stock Exchange. It is worth noting that, however, several fundamental differences, ranging from whether the regulation is indeed practiced to the operational details of the warrant origination mechanism, exist between the two stock exchanges.

First and foremost, although the Shenzhen Stock Exchange passed a similar regulation regarding warrant origination, the exchange did not encourage or allow its practice. As a matter of fact, not a single share of additional warrant contract was originated by the brokerage firms. Second, according to the regulation, warrants issued after original issuance cannot start trading until two days after the origination in Shenzhen whereas trading can take place as early as the same day of origination at the Shanghai Stock Exchange. Finally, the two stock exchanges have different requirements for the deposits/collaterals that brokerage firms have to put down for originating additional warrants.

Because the two stock exchanges and the stocks listed at these two stock exchanges are otherwise largely similar (please see Liao, Li, Zhang and Zhu (2010) for a detailed comparison between the two exchanges), we feel that a contrast between the pricing properties of warrants listed at the respective stock exchange provides an interesting opportunity to investigate the impact of security supply and short sale on the formation of bubbles in the securities markets.

## Section 3. Hypothesis and Methodology

### 3. 1 Hypothesis Formation

Short sales should reduce market mis-pricing and bubbles in asset prices. Therefore, we expect that Shanghai-listed warrants are less likely to deviate from their fundamental prices than Shenzhen-listed warrants

**Hypothesis 1.** Shanghai-listed warrants deviate from their fundamental values by a lower frequency than Shenzhen-listed warrants do.

Following the above logic, we expect that if warrant prices were to deviate from their fundamental values, the availability of short sales should at least be able to reduce the likelihood of bubble formation and limit price deviation away from fundamental values. Put differently, we expect that Shanghai-listed warrants deviate less from their fundamental values, on average, than Shenzhen-listed warrants.

**Hypothesis 2**. Shanghai-listed warrants deviate from their fundamental values by a smaller magnitude than Shenzhen-listed warrants do.

### 3. 2 Methodology

#### 3.2.1 Occurrence of Deviation from Fundamental Price

As Xiong and Yu (2009) argue, the Chinese warrants market provides a unique opportunity to study the case of bubbles because warrants are often traded at prices that far exceed the level warranted by their fundamental values (we use "fundamental value",

"fundamental price", "theory price", and "intrinsic value" interchangeably throughout the rest of the paper).

Similar to their methodology, we also estimate the fundamental value of the warrants by using the Black-Scholes approach.[14] In particular, the prices of a European call (C) and put (P) are given by $C = Se^{-yt}N(d_1) - Xe^{-rt}N(d_2)$ and $P = Se^{-yt}(N(d_1)-1) - Xe^{-rt}(N(d_2)-1)$, where $d_1 = \frac{Ln(\frac{S}{X}) + (r + \frac{\sigma^2}{2})t}{\sigma\sqrt{t}}$ and $d_2 = d_1 - \sigma\sqrt{t}$. $N(x)$ is the cumulative distribution function of the standard normal distribution; $S$ is the spot price of the underlying asset; $t$ is time to maturity of the warrant; $X$ is the strike price; $r$ is the risk-free rate in terms of continuous compounding; $\sigma$ is the annual volatility of the underlying asset.

Several issues merit further discussions regarding the calculation of over-pricing. First, consistent with Xiong and Yu (2009), we also use a model-free approach to value warrants and obtain very consistent and similar results as their study. Further, it is worth noting that, similar to Xiong and Yu (2009), we use historical volatility, instead of the implied volatility, in applying the Black-Scholes model when valuing warrants. We acknowledge this is our best-effort attempt with the absence of data on implied volatility. Finally, because of some nuances in how closing prices for stocks and warrants are calculated, there are some slight differences between our study and that of Xiong and Yu (2009).

[14] The short sales constraint and the stock price dynamics which may not follow a geometric Brownian motion process in China may hurt the accuracy of Black-Scholes pricing. These considerations caution us not to over-interpret the exact intrinsic values of warrants. However, as argued by Xiong and Yu (2009), "while one might argue that the Black-Scholes model may not be accurate in measuring fundamental values of the Chinese warrants, a Black-Scholes value of less than 0.05 penny is a reliable indication that the warrant only has a tiny probability, if any, of being in the money at expiration and that it has virtually no value".

Once we obtain the fundamental value of warrants based on the Black-Scholes model, we next estimate the number of days and the fraction of days that warrants traded at "unreasonably high" prices. Because the fundamental values are often small (close to zero) for many of the warrant contracts, we feel that a single measure that is based on either the dollar-value deviation or percentage deviation may not accurately capture the extent of the bubbles. Instead, we adopt three different measures to illustrate our results.

First, we calculate the number and fraction of days that warrants trade at prices that are at least 0.5 Yuan greater (or lower, which is far less often) than their fundamental values. Given that the average theory price of put warrants is 1.20 Yuan (median 1.02 Yuan), we feel that a 0.5 Yuan deviation constitutes a significant deviation of warrant prices from their fundamental values. Second, we calculate the number and fraction of trading days when warrants trade at prices that are at least 50 percent higher (or lower, which is far less often) than their fundamental values. Third, similar to Xiong and Yu (2009), in unreported results, we calculate the number of days that warrants traded at positive prices even though there is no intrinsic value in such warrants and obtain consistent results.

### 3.2.2 Magnitude of Deviation from Fundamental Price

We calculate the magnitude of deviation from fundamental prices, in both dollar and percentage terms. For dollar term, we calculate the absolute value of the difference between the closing price of a warrant and the fundamental value of the warrant according to our Black-Scholes calculation. Because warrants are traded at prices above their fundamental values most of the time[15], our results remain very similar if we calculate the difference, instead of the

[15] Fraction of deviation from fundamental value is 93.37 percent for put warrants and 71.58 for call warrants.

absolute value of the difference. Next, we calculate the percentage deviation to the intrinsic value of warrant contracts. In particular, the percentage deviation of warrant contracts is calculated as

$$\text{Percent Deviation} = \text{Dollar deviation} / \text{intrinsic value}$$

where dollar deviation is defined as above and the intrinsic value is calculated by following the formula and procedure described in Section 3.2.1.

We acknowledge that there are weaknesses to both approaches. If warrants listed at one stock exchange trade at much higher prices, then it is possible that the market at which warrants trade at higher prices may observe, on average, greater differences between market prices and their fundamental values due to the differences in base values. In contrast, it is conceivable that the market at which warrants trade at lower prices may observe, on average, greater differences in percentage terms because of the relatively lower price levels (denominators). Therefore, we believe that the two approaches that we adopt can complement each other and we can reach reliable conclusions if both measures point into the same direction (which is the case for our empirical results).

### 3.2.3 Warrant Supply and Bubbles

One interesting feature of the warrant origination mechanism at the Shanghai Stock Exchange is that qualified brokerage firms may choose to originate (supply) additional warrants at different times and especially during periods when the brokerage firms find the warrant prices are significantly overpriced and therefore it most lucrative to sell additional warrants to the market.

In addition to our main analysis, we conduct additional analysis that takes advantage of the time-series variation in the supply of warrants. For each contract with additional warrant origination (all of the 10 put warrants listed at the Shanghai Stock Exchange and all of the 17 call and put warrants listed at the Shanghai Stock Exchange), we trace the increase of number of warrants available for trading at the market. For each warrant, we identify the trading day when the market witnessed the largest increase in the number of warrants available for trading. Large increases in the number of warrants suggest that the brokerage firms provide additional supplies of warrants to the market. We expect that, the number of warrants available to trade reaching its maximum, in addition to the potential bear views signaled by the brokerage firms' supplying additional warrants, should alert investors of potential risks and discourage them from engaging in further speculation in the market. As a result, we repeat the above exercises in Section 3.2.1 and Section 3.2.2 for the sub-sample of warrants that experienced additional issuance, for a brief period immediately before and after the date when the total number of tradable warrants reaches its maximum. If the additional warrant issuance matters to bubbles, we expect that the frequency and extent of bubbles to decrease after such event.

## Section 4. Data Description

By June 30, 2010, a total of 55 warrants were issued and transacted on the Shanghai Stock Exchange and Shenzhen Stock Exchange. Out of the 55 warrants, 37 warrants were call warrants and the remaining 18 were put warrants. Classified based on the listing stock exchange, 39 warrants were listed on the Shanghai Stock Exchange and the remaining 16 were listed on the Shenzhen Stock Exchange. Of the 39 warrants listed at the Shanghai Stock Exchange, new warrants were originated and sold to the market for 17 warrants, with 7 of them on call warrants

and the remaining 10 on put warrants. In contrast, no new warrants were supplied to the market for all of the 16 warrants listed at the Shenzhen Stock Exchange.

We obtain data on 17 put warrants[16] from RESSET Financial Research Database (www.resset.cn) and report their summary statistics in Table 1. The main reason for choosing the put warrants as the sample of our study is that the put warrant prices (mean 1.20 Yuan) are typically much lower than the call warrant prices (mean 9.63 Yuan) in China, which makes the put warrants attract more speculative investments and hence create more and greater bubbles.[17] For example, the average percentage premium of put warrants over their fundamental values is 269.68 percent, while that of call warrants is only 7.12 percent. In addition, as Xiong and Yu (2009) point out, it is more reliable to estimate the fundamental price of put warrants for a larger fraction of the sample. In unreported analysis, we replicate our main analysis for the sample of call options and obtain consistent results.

(Insert Table 1 about here)

The average maturity of the put warrants is 420.65 days with a median of 183 days. The average market capitalization of underlying stocks is 5.83 billion Yuan, with the average capitalization for warrants with new issuance (6.53 billion Yuan) higher than that for warrants without new issuance (4.83 billion Yuan). As indicated in Table 2, on average, the put warrants are traded at 1.20 Yuan and their average theory value is only 0.32Yuan. The average market

[16] We exclude one American-style warrant during the sample period since the Black-Scholes formula cannot be used to accurately price American options.

[17] For example, Zhu et al. (2010) show with experiments that retail investors have a strong preference for stocks that split because they feel that lower-priced stocks are "cheap".

price is significantly higher than the average theory value for both the Shanghai-listed warrants and Shenzhen-listed warrants at the 1 percent. Figure 1 provides a more detailed demonstration on how the warrant market prices and theory prices are distributed.

(Insert Figure 1 about here)

Table 2 reports that there are also some noticeable differences between the average market (theory) prices for warrants listed at the Shanghai Stock Exchange and the Shenzhen Stock Exchange. The average market (theory) price for the Shanghai-listed warrants is 0.86 (0.27) Yuan whereas that for the Shenzhen-listed warrants is 1.58 (0.38) Yuan. As for the premium of market prices over the corresponding theory prices, the average premium for warrants with new issuance is 0.59 Yuan and that for those without new issuance is 1.19 Yuan. The above differences are all significant at the 1 percent, providing some preliminary support to our hypothesis that the warrants that experienced additional issuance trade at relatively more reasonable prices. We will investigate the incidence and extent of bubbles in greater details in Section 5.

(Insert Table 2 about here)

## Section 5. Empirical Results

### 5.1 Warrant Issuance and Frequency of Over-pricing

We first investigate the frequency at which warrants trade at prices that are considerably higher than their fundamental values. Because the theoretical values of different warrant contracts vary considerably, and the magnitude of the difference between transaction price and

theory price is influenced by the theory price of a warrant, we group all warrants into six categories based on their theory values[18]. In particular, we divide all warrant contracts into six categories following the criteria below:[19]

Class 1: If warrant's theory price is zero[20]

Class 2: if warrant's theory price is no smaller than zero but smaller than 0.001 Yuan

Class 3: if warrant's theory price is no smaller than 0.001 Yuan and smaller than 0.01 Yuan

Class 4: if warrant's theory price is no smaller than 0.01 Yuan and smaller than 0.1 Yuan

Class 5: if warrants' theory price is no smaller than 0.1 Yuan and smaller than 1 Yuan

Class 6: if warrant's theory price is no smaller than Yuan

Table 3 indicates that, according to our calculation based on the Black-Scholes formula, about 55 percent of the warrants are valued between 0.01 and 1 Yuan, with about 35 percent of the warrants valued at below 0.01 Yuan and the remaining 10 percent valued at above 1 Yuan.

(Insert Table 3 about here)

We first focus on the absolute deviation in dollar term when studying the frequency of bubble occurrences. In particular, we examine the closing price of each warrant contract on each

[18] We perform robustness tests by grouping based on warrants' transaction prices and the results are very similar.

[19] We experiment with alterative cut off points and our results remain robust with the classification method.

[20] Similar to Xiong and Yu (2009), we can identify warrants with zero intrinsic value because of the regulation on daily price movement limit for stocks and warrants.

trading day and define a warrant as "in bubbles" if the closing price for the warrant is at least 0.5 Yuan greater than its theoretical intrinsic value. Our analysis in Panel A of Table 4 reveals that bubbles are more likely to form for warrants without new issuance than those with new issuance within all six categories classified by different levels of fundamental values. For four out of the six categories, the Shenzhen-listed warrants are significantly far more likely to trade at prices that are at least 0.5 Yuan higher than their fundamental values. In particular, for Class 5 which includes warrants with theory prices between 0.1 and 1 Yuan and covers 41.3 percent of the total observations, the Shanghai-listed warrants deviate from their fundamental values by 0.5 Yuan or more for 40.8 percent of the trading time. In contrast, the occurrence of such considerable deviation is far more often at 60.81 percent for the Shenzhen-listed warrants. The frequencies of such considerable deviation from warrants' fundamental values for the Shenzhen-listed warrants and Shanghai-listed warrants have no significant difference in Class 1 and Class 3, which only include 11.84 percent of the total observations.

(Insert Table 4 about here)

Next, we examine the frequency of percentage price deviation of warrant prices from their fundamental values measured by percentage terms. A warrant is defined as "in bubbles" if its closing price is at least 50 percent greater than the corresponding theoretical value. To overcome potential sensitivity of our definition, we also experiment with alternative definition such as using 0.25 Yuan or 1 Yuan to define bubbles in dollar value and using 25 percent or 100 percent to define bubbles in percentage. We obtain very similar results. Because the percentage deviation is very big and hard to compare for those warrants with very low prices, we focus our attention on warrants whose theoretical price is at least 0.001 Yuan.

Our results in Table 4 Panel B show that, consistent with previous results on frequency of absolute price deviation, bubbles are more likely to occur for warrants without additional issuance. Since the percentage price deviation is bigger than 50% for almost all of the trading time when the theory price of a warrant is less than 0.1 Yuan, we find no significant difference between the frequencies of percentage deviation for the Shenzhen-listed warrants and Shanghai-listed warrants in Class 3 and Class 4. For Class 5, the Shanghai-listed warrants deviate from their theory prices by 50% or more for 74.94 percent of the trading time, while the occurrence of such considerable deviation is 82.87 percent for the Shenzhen-listed warrants. When the theory price is greater than 1 Yuan (Class 6), the frequency of a 50% or more deviation is only 2.34 percent for the Shanghai-listed warrants, and it is much bigger at 14.75 percent for the Shenzhen-listed warrants. The differences are highly statistically significant at the 1 percent level for both classes.

In sum, our above analysis confirms that new warrant issuance can reduce the likelihood of warrants to trade at price levels that are considerably higher than their fundamental values and provides strong support for our Hypothesis 1. Next, we investigate whether new warrant issuance is also effective in influencing the level of over-pricing for warrants with and those without new issuance.

5.2 Warrant Issuance and Magnitude of Price Deviation

We next investigate the absolute differences between warrant prices and their fundamental values. We first calculate the differences between the transaction price and the theory price of each warrant on each trading day. Because the deviation calculated in this approach is heavily influenced by the theory values of the warrant contracts, we study such

deviations for sub-groups of warrants with different fundamental prices as described in Section 5.1.

Panel A of Table 5 reports the results contrasting the difference between warrant transaction price and its theory price. The most striking result is that for all six groups of warrants classified based on fundamental prices, the premium of transaction price over fundamental price is smaller for the group of warrants that experienced new issuance than for the group of warrants that did not experience new issuance. For example, for the warrants with zero theory value, the warrants without new issuance trade at an average of 0.66 Yuan and the ones with new issuance trade at an average of 0.33 Yuan. That is, the premium at which warrants that did not experience new issuance command, is almost twice as high as the premium that warrants without new issuance command. Such a difference is significant at the 10 percent level, due to the relatively small sample size.

(Insert Table 5 about here)

The results are very similar for warrants with theory price between 0.001 and 1 Yuan. The differences between transaction prices and fundamental prices for the group of warrants without new issuance are significantly bigger than those for the group of warrants with new issuance. In the extreme case of Class 2, which includes warrants with theory price below 0.001 Yuan, the premium for warrants without new issuance (2.56 Yuan) is more than three times as big as that for warrants with new issuance (0.73 Yuan). The differences are highly statistically significant at the 1 percent level for all four groups.

Consistent with the results reported so far, the warrants without new issuance are priced higher than for those with new issuance for Class 6, those warrants with fundamental price

greater than 1 Yuan. Such a difference is both highly statistically significant and economically meaningful. It is worth noting, however, that warrants with new issuance in Class 6 are on average traded at a modest discount, instead of a premium and such a discount is not statistically significant. We suspect that this may have something to do with the phenomena that speculative investors are more interested in trading lower-priced warrants.[21]

Next, we examine the percentage price deviation of warrant prices from their fundamental values. In particular, we calculate the ratio of the deviation between warrant transaction price and its fundamental value for each warrant on each day as described in Section 5.1. Because the percentage deviation is very big and hard to compare for those warrants with very low prices, we focus our attention on warrants whose theoretical price is at least 0.001 Yuan. Our results in Table 5 Panel B show that, consistent with previous results on absolute price difference, the percentage price deviation results confirm that warrants with additional issuance display weaker over-pricing than warrants without additional issuance.

Not surprisingly, the percentage premium is on average much higher for lower-priced warrants than for higher-priced warrants. For example, for warrants with theory price between 0.001 and 0.01 Yuan, the percentage difference is 223.03 percent for warrants with new issuance and 488.55 percent for those without new issuance. As warrant theory price increases, the percentage deviation of warrant transaction price from theory price decreases. For warrants with theory price between 0.01 and 0.1 Yuan, the percentage deviation is 34.45 percent for warrants with new issuance and 58.14 percent for warrants without new issuance. For the highest-priced

[21] Because the percentage price deviation is greater for lower-priced than for higher-priced warrants (because of the much smaller denominator), lower-priced warrants provide greater incentives for speculative investments.

warrants with theory price above 1 Yuan, the warrants with new issuance again observe a discount of about 0.07 percent. That is, warrants trade at a slightly lower price than their fundamental values. In contrast, warrants without new issuance trade at a premium of 0.11 percent over their fundamental values.

The key to the results from all four groups is that the warrants with new issuance display much smaller percentage premium over their theory prices than warrants without new issuance do. Further, within respective class, the differences between these two groups are all highly significant.[22] Consistent with our hypothesis, brokerage firm's issuance of new warrant contracts seems able to reduce the differences between warrants' transaction prices and their corresponding theory prices. More specifically, because warrants trade at price levels that are apparently higher than their fundamental values predicted by theory, such over-pricing can be taken as evidence of a bubble (Xiong and Yu (2009)). To our best knowledge, our evidence shows for the first time with field evidence that security supply, which is the necessary condition for short sales, can relatively reduce the extent of asset bubbles.

5.3 Over-Pricing around Additional Warrant Issuance

To control for potential differences between warrants, we next focus on the sub-sample of warrants with new issuance and examine whether there is significant change in pricing premium (absolute difference between warrant transaction prices and warrant fundamental prices)[23], for

[22] The result is significant at the 5 percent level for Class 5.

[23] The theory warrant prices are typically very low (lower than 0.001 Yuan) around the new issuance. As a result, the frequency of over pricing is almost 100 percent both before and after the issuance. In addition, the percentage

the period immediately before and after additional warrant issuance, for the very same warrants.[24] If our conjecture that additional warrant issuance is responsible for the drop in security overpricing, we expect to find that the pricing premium decreases after the introduction of additional warrants to the market. Such a change-in-change approach should complement our aggregate results so far contrasting the pricing premium between the warrants with- and without-additional issuance and provide a sharper focus on the event of additional warrant issuance.

In particular, we divide the life span of each warrant contract by the date on which the number of tradable warrants reaches its highest level. Because brokerage firms keep issuing new warrants and buying back newly created warrant contracts, the total net number of warrants issued on a stock changes over time. As a result, the date when the total net number of newly issued warrants reaches its maximum reflects the largest number of supply increases and hence should have strong impact on the likelihood and extent of warrants to trade at considerably higher levels than their fundamental values.[25] Panel A of Table 6 shows similar patterns to those reported in Table 5. When comparing the degree of over-pricing for the 5-day window, the absolute difference between warrant transaction prices and their fundamental values is significantly higher before additional warrant issuance (0.88 Yuan) and becomes much smaller

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deviation is very high both before and after the new issuance due to the very small denominator of theory prices. As a result, we do not compare the frequency and percentage deviation before and after the new issuance event.

[24] For the window of 5-trading days, the frequency of a more than 0.5 Yuan (or 50%) deviation is almost 100% both before and after the maximum new issuance.

[25] We experiment with alternative classification methods by using the date with the largest increase in the number of tradable warrants or the date when the first additional issuance is originated by brokerage firms and our results remain similar.

after additional issuance (0.76 Yuan). This difference is mainly driven by a significant decrease in market price, since the theory prices only change marginally before and after the maximum cumulative new issuance. It is worth noting that the above difference in pricing premium is significant at the 10 percent level. We suspect that the small sample of ten warrants is partly responsible for such a result.

(Insert Table 6 about here)

To mitigate the limitations of inferences from the small sample of put warrants, we also report the summary of our results for both call and put warrants. Although put and call warrants vary considerably in their fundamental prices, we feel that there are two advantages of including the call warrants. First, including the call warrants can increase our sample size from 10 warrants to 17 warrants and strengthen the power of our statistical tests. Further, the pair-wise tests are less sensitive to the differences in the fundamental prices of the securities. The combined sample provides very consistent results in Panel B to those in Panel A of Table 6: the pricing premium indeed decrease considerably (by about 20 percent) and the results are statistically significantly (at the 5 percent level).

(Insert Table 7 about here)

In addition to the above aggregate-level analysis, we also conduct such event study for individual warrants around the date with the maximum cumulative new issuance and present our results in Table 7. To conserve space, we do not report the magnitude of the difference between transaction price and fundamental price. Instead, we report the direction and significance of the

change in the pricing premium before and after new warrant issuance. Among the ten put warrants, six witnessed decrease in premiums (three being significant at the 5 percent level) and four witnessed increase in premium (none being significant at the 5 percent level). Such results confirm that pricing premium become smaller after additional warrant issuance.

Similar to the results in Table 6, we also include the seven call warrants with additional issuance to expand our sample. Among the seven call warrants, five witnessed decrease in premiums (three being significant at the 10 percent level) and two witnessed increases in pricing premiums (none being significant). Such results further strengthen our conclusion that additional issuance helps reduce bubbles.[26]

In addition, we adopt an alternative definition that divides the trading history of each warrant contract by the time that brokerage firms first issue new warrants. Our analysis generates consistent results. The degree of over-pricing of warrants is significantly smaller after than before the first new issuance. We implement additional exercises that examine the relatively longer event window of 10- and 15- trading days and obtain similar results. Such results are available from the authors upon request.

In sum, our above difference-in-difference results provide further and more precise evidence that the issuances of new warrants, in addition to any known differences in firm characteristics such as firm size or valuation level, are responsible for variations in the pricing premium in the Chinese warrants' market.

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[26] The chi-square test comparing the proportion of warrants witnessing decrease in price premium after maximum cumulative issuance with 50 percent generates insignificant results for the sample of put warrants and the sample of combined call and put warrants. This is probably due to the small sample size.

5.4 Regression Results

We next perform regression analysis to control for potential confounding factors that may influence the pricing of warrant contracts and perform regressions that focus on only stocks that experienced new warrant issuance. Such event-study type of analysis can investigate whether the new issuance event can alter the magnitude of over-pricing and bubbles. Specifically, the regressions take the following specification for the sample of ten warrants that experienced additional issuance. For each warrant, the sample includes the five-day-period immediately before- and after- the date with maximum new issuance. In sum, the sample of put warrants includes 99 observations and the sample of combined call and put warrants include 169 observations.[27]

$$\begin{aligned}\text{Premium} = a &+ b_1 * \text{Dummy(max new issuance)} + b_2 * \text{Raito of max new issuance} + b_3 * \text{Theory price} \\ &+ b_4 * \text{Time to maturity} + b_5 * \log(\text{Cap. of warrant}) + b_6 * \text{Trading vol. of warrant} \\ &+ b_7 * \text{Cap. of stock} + b_8 * \text{Trading vol. of stock} + b_9 * \text{dummy (state-owned stock)}\end{aligned}$$

The dependent variable is the magnitude of price premium from the theoretical warrant value. Maximum new issuance is a dummy variable that takes a value of one for days after the maximum cumulative new issuance. Ratio of maximum new issuance is defined as the ratio of the maximum shares of net new issuance to the shares of initial issuance. Theory price is the intrinsic warrant value calculated by Black-Scholes formula for each trading day. Time to maturity is the number of calendar days left to the expiration of the warrant. The capitalization of warrant is the logarithm of the product of the total number of warrant contracts times the warrant closing price (in hundred million Yuan). Trading volume of warrant is the log transformation of

[27] One warrant experienced maximum net new issuance on the fourth trading day after its initial issuance.

the total dollar value of transactions of each warrant (in hundred million Yuan). The market capitalization of underlying stock and the trading volume of underlying stock equal the log transformation of the total market capitalization of the float shares (calculated as the number of float shares multiplied by the closing price on that day) and total value of all transactions. State-owned stock is a dummy variable that takes a value of one if the company is a state-owned enterprise and zero otherwise.

Our results in Table 8 indicate that the premium of warrants over their fundamental values are determined by several factors, including the event of maximum cumulative new issuance, fundamental price of warrants, time to maturity of warrants, market capitalization of warrants, market capitalization of the underlying stocks, and trading volume of the underlying stocks. The most interesting result is that after control for potential factors that may influence the premium of warrants, the event of maximum cumulative new issuance still has significant impact on the pricing of warrants at the 5 percent. The negative coefficient on the dummy variable of maximum new issuance indicates that price premium from the theoretical warrant value decreases after the maximum cumulative new issuance. We also implement a step-wise regression and find that the dummy variable of the event of maximum cumulative new issuance is included in the optimal regression model. To conserve space, we do not report the detailed results of step-wise regression.

Further, we replicate the regression results for the combined sample of call and put warrants. Similar to the results for the put-only sample, the dummy variable for the event of maximum cumulative new issuance is negative and highly significant. The coefficient of the ratio of maximum cumulative new issuance and theory price changes into the opposite signs. We

suspect that this is due to the differences in prices and additional issuance activities between the call and the put warrants.

(Insert Table 8 about here)

5.5 Robustness Tests

To alleviate the concerns that the differences in the characteristics of underlying stocks may drive our results, we divide our whole sample of observations into two sub-groups based on company market capitalization, the book-to-market ratio of companies, the age of companies, and the dummy variable of whether the company is a state-owned enterprise or not. Our main findings hold in respective sub-samples[28].

Because the Chinese stock market went through drastic price movement and some considerable overhauls in disclosure regulations, we repeat our main analysis within each calendar year 2006, 2007, and 2008. Our main results hold qualitatively within each individual year.

In addition, we conduct a robustness test by using the opening price of warrants, instead of the closing price to control for potential daily price swings, as the benchmark market price to calculate the deviation of market price from the theory value, and obtain very consistent results.

## Section 6. Conclusions

[28] The statistical significance falls down to the 10 percent level in some cases due to the decrease in sample size.

We document that the mechanism that allow additional supply of securities to the market can reduce the frequency and extent of bubbles taking place at the Chinese warrants market. At the Shanghai Stock Exchange, where brokerage companies are allowed to provide additional shares of warrants to the market, warrants trade at prices that deviate from their fundamental values far less often. Further, the deviation of warrant transaction price away from the intrinsic value is also significantly smaller for warrants listed at the Shanghai Stock Exchange than that for warrants listed at the Shenzhen Stock Exchange, which does not allow additional shares to be provided to the market. Company characteristics, such as size, book-to-market, financial soundness, and sector differences cannot explain our results. Instead, warrant pricing changes across the introduction of additional contracts to the market strengthen our main results: there are noticeable reductions in the extent of price deviation from fundamental value after brokerage firms' supply of additional shares to the market.

Our findings that warrants with new issuance also trade at considerably higher prices than their fundamental values, support prior studies that short sales cannot completely prevent or remove asset bubbles (Haruvy, Yaron and Noussair (2007)). Further, our evidence suggests that the degree of bubbles depends on the level of securities' fundamental value, the characteristics of the securities (i.e. the type of warrants and the time to maturity), and the characteristics of the underlying stocks (market capitalization and trading volume of the underlying stock). Our findings therefore point out the complexity of reasons behind the formation of bubbles in the securities and future research is needed to further extend the literature on bubbles.

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**Figure 1. Distribution of Warrant Market Prices and Intrinsic Theory Prices**

This figure plots the histograms of the warrant market prices and theory prices. The market (theory) prices are classified into eight groups as follows: price between 0 and 0.001 Yuan, price between 0.001 and 0.1 Yuan, price between 0.1 and 0.5 Yuan, price between 0.5 and 1 Yuan, price between 1 and 2 Yuan, price between 2 and 3 Yuan, price greater than 3 Yuan.

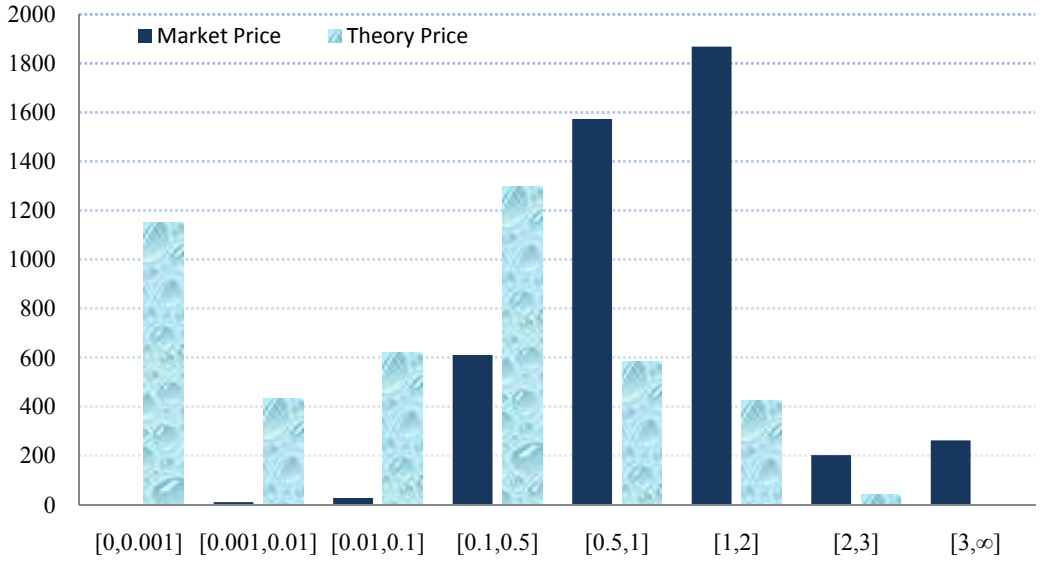

**Table 1. Summary Statistics**

This table provides the summary statistics of our sample. Panel A reports the total number of warrants, the number of warrants with new issuance and those without new issuance. Panel B reports the average, median, minimum, and maximum maturity for warrants with new issuance and those without new issuance. Panel C reports the average market capitalization and average daily turnover of the underlying stocks for groups of warrants with and without new issuance. Calculation of average market capitalization and average daily turnover of underlying stocks are based on data 60 trading days immediately before the initial issuance of warrants.

| | Total | With New Issuance | W/o New Issuance |
|---|---|---|---|
| Panel A. Sample of Warrants | | | |
| Shanghai-Listed | 10 | 10 | 0 |
| Shenzhen-Listed | 7 | 0 | 7 |
| Total | 17 | 10 | 7 |
| Panel B. Expiration of Warrants | | | |
| Mean | 420.65 | 376.90 | 483.14 |
| Median | 183 | 300 | 183 |
| Std. Dev | 150.36 | 63.51 | 215.63 |
| Panel C. Characteristics of Underlying Stocks | | | |
| Avg. Market Cap | 5.83 | 6.53 | 4.83 |
| Avg. Daily Turnover | 1.87% | 1.92% | 1.79% |

**Table 2. Bubbles in the Warrants Market: Warrant Prices**

This table shows the average market price and average theory price for all warrants, warrants with and without new issuance. This table also shows the deviation of market price from the corresponding theory price for different groups of warrants, as well as the difference in market prices, difference in theory prices, and difference in price deviations for groups of warrants with and without new issuance. P-value of Students' t-test is also reported for each set of comparison.

| | Total | With New Issuance (A) | W/o New Issuance (B) | Diff: A - B | P-value (t-test) |
|---|---|---|---|---|---|
| Avg. Market Price (I) | 1.1953 | 0.8642 | 1.5755 | -0.7113 | <.0001 |
| Avg. Theory Price (II) | 0.3233 | 0.2716 | 0.3828 | -0.1112 | <.0001 |
| Diff: I – II | 0.8720 | 0.5926 | 1.1927 | -0.6001 | <.0001 |
| P-value (t-test) | <.0001 | <.0001 | <.0001 | <.0001 | / |

**Table 3. Classification of Warrants based on Theory Price**

This table shows the criteria that we used to divide all warrant contracts into six categories. The number of observations and percentage of observations for each category are also reported for all warrants, warrants with and without new issuance.

| Class | Price Interval | Total | | With New Issuance | | W/o New Issuance | |
|---|---|---|---|---|---|---|---|
| | | Observations | Percentage | Observations | Percentage | Observations | Percentage |
| 1 | P=0 | 105 | 2.31% | 59 | 2.42% | 46 | 2.17% |
| 2 | 0<P≤0.001 | 1048 | 23.01% | 555 | 22.80% | 493 | 23.25% |
| 3 | 0.001<P<=0.01 | 434 | 9.53% | 216 | 8.87% | 218 | 10.28% |
| 4 | 0.01<P<=0.1 | 619 | 13.59% | 307 | 12.61% | 312 | 14.72% |
| 5 | 0.1<P<=1 | 1881 | 41.30% | 1169 | 48.03% | 712 | 33.58% |
| 6 | P>1 | 467 | 10.25% | 128 | 5.26% | 339 | 15.99% |

## Table 4. Frequency of Deviation from Warrant Fundamental Value

This table reports the number observations and corresponding frequency that warrant market prices deviate from their fundamental values by 0.5 Yuan (50%) or more for each category for groups of warrants with and without new issuance. As the percentage deviation is very big and hard to compare for those warrants with very low prices, we only calculate the frequency of percentage price deviation for warrants whose theoretical price is at least 0.001 Yuan (Class 3 – Class 6). Chi-square tests are performed for comparing the frequency of over-pricing for warrants with and without new issuance.

| Class | Observations | | Frequency | | P-value ($\chi^2$-test) |
|---|---|---|---|---|---|
| | With New Issuance (A) | W/o New Issuance (B) | With New Issuance (A) | W/o New Issuance (B) | |
| Panel A. Absolute Price Deviation > 0.5 Yuan | | | | | |
| 1 | 10 | 14 | 16.95% | 30.43% | 0.1025 |
| 2 | 381 | 447 | 68.65% | 90.67% | <.0001 |
| 3 | 168 | 171 | 77.78% | 78.44% | 0.8674 |
| 4 | 234 | 277 | 76.22% | 88.78% | <.0001 |
| 5 | 377 | 433 | 40.80% | 60.81% | <.0001 |
| 6 | 3 | 70 | 2.34% | 20.65% | <.0001 |
| Panel B. Percentage Price Deviation ≥ 50% | | | | | |
| 1 | / | / | / | / | / |
| 2 | / | / | / | / | / |
| 3 | 216 | 217 | 100.0% | 99.54% | 0.3190 |
| 4 | 306 | 312 | 99.67% | 100.0% | 0.3130 |
| 5 | 876 | 590 | 74.94% | 82.87% | <.0001 |
| 6 | 3 | 50 | 2.34% | 14.75% | 0.0002 |

## Table 5. Magnitude of Deviation from Warrant Fundamental Value

This table reports the magnitude of deviation of warrant market price from the fundamental value, in both dollar and percentage terms, for each category for warrants with and those without new issuance. This table also shows the difference of deviations for groups of warrants with and without new issuance, and the corresponding P-value of Students' t-test. Since the percentage deviation is very big and hard to compare for those warrants with very low prices, we only calculate the percentage price deviation for warrants whose theoretical price is at least 0.001 Yuan (Class 3 – Class 6).

| Class | Group | Sample | Premium | Std. Dev | Diff: A - B | P-value (t-test) |
|---|---|---|---|---|---|---|
| Panel A. Absolute Price Deviation | | | | | | |
| 1 | With New Issuance (A) | 59 | 0.3305 | 0.2140 | -0.3276 | 0.0531 |
| | W/o New Issuance (B) | 46 | 0.6581 | 1.1041 | | |
| 2 | With New Issuance (A) | 555 | 0.7315 | 0.3781 | -1.8291 | <.0001 |
| | W/o New Issuance (B) | 493 | 2.5605 | 1.6607 | | |
| 3 | With New Issuance (A) | 216 | 0.7425 | 0.4024 | -0.5908 | <.0001 |
| | W/o New Issuance (B) | 218 | 1.3333 | 0.9363 | | |
| 4 | With New Issuance (A) | 307 | 0.8463 | 0.4508 | -0.5217 | <.0001 |
| | W/o New Issuance (B) | 312 | 1.3680 | 0.9131 | | |
| 5 | With New Issuance (A) | 1169 | 0.5325 | 0.4989 | -0.1400 | <.0001 |
| | W/o New Issuance (B) | 712 | 0.6717 | 0.4142 | | |
| 6 | With New Issuance (A) | 128 | -0.2002 | 0.4497 | -0.3188 | <.0001 |
| | W/o New Issuance (B) | 339 | 0.1186 | 0.3873 | | |

| Class | Group | Sample | Premium | Std. Dev | Diff: A - B | P-value (t-test) |
|---|---|---|---|---|---|---|
| Panel B. Percentage Price Deviation | | | | | | |
| 1 | With New Issuance (A) | 59 | / | / | / | / |
| | W/o New Issuance (B) | 46 | / | / | | |
| 2 | With New Issuance (A) | 555 | / | / | / | / |
| | W/o New Issuance (B) | 493 | / | / | | |
| 3 | With New Issuance (A) | 216 | 223.03% | 162.71% | -265.52% | <.0001 |
| | W/o New Issuance (B) | 218 | 488.55% | 643.17% | | |
| 4 | With New Issuance (A) | 307 | 34.45% | 32.12% | -23.68% | <.0001 |
| | W/o New Issuance (B) | 312 | 58.14% | 55.73% | | |
| 5 | With New Issuance (A) | 1169 | 1.91% | 2.15% | -0.24% | 0.0390 |
| | W/o New Issuance (B) | 712 | 2.15% | 2.62% | | |
| 6 | With New Issuance (A) | 128 | -0.07% | 0.29% | -0.18% | <.0001 |
| | W/o New Issuance (B) | 339 | 0.11% | 0.32% | | |

**Table 6. Deviation around the Event of Maximum Cumulative New Issuance**

This table reports the average market price, theory price and price deviation before and after the event of maximum cumulative new issuance. The difference in market prices (theory prices, price deviations) before and after the event, and the corresponding significance are also reported.

| | Before the Event | After the Event | Diff: After – Before | P-value (t-test) |
|---|---|---|---|---|
| Panel A. Put Warrants | | | | |
| Market Price | 1.0155 | 0.8847 | -0.1308 | 0.1849 |
| Theory Price | 0.1401 | 0.1274 | -0.0127 | 0.0697 |
| Price Deviation | 0.8754 | 0.7573 | -0.1181 | 0.0674 |
| Panel A. Put and Call Warrants | | | | |
| Market Price (A) | 2.5587 | 2.4188 | -0.1399 | 0.3654 |
| Theory Price (B) | 1.6763 | 1.6391 | 0.0372 | 0.0384 |
| Price Deviation | 0.9196 | 0.7425 | -0.1771 | 0.0451 |

## Table 7. Event Study

This table reports the direction of change and significance of the change in the pricing premium before and after maximum cumulative new issuance for each warrant for the event window of 5--trading days. A "+" sign indicates an increase in pricing premium after additional issuance while a "-" sign indicates a decrease in pricing premium.

| Warrant Identifier | Put Warrants | | Put and Call warrants | |
|---|---|---|---|---|
| | Direction | P-value (t-test) | Direction | P-value (t-test) |
| 580989 | + | 0.1917 | + | 0.1917 |
| 580990 | - | 0.0043 | - | 0.0043 |
| 580991 | + | 0.3310 | + | 0.3310 |
| 580992 | + | 0.0599 | + | 0.0599 |
| 580993 | - | 0.1323 | - | 0.1323 |
| 580994 | + | 0.9053 | + | 0.9053 |
| 580995 | - | 0.3027 | - | 0.3027 |
| 580996 | - | 0.0093 | - | 0.0093 |
| 580997 | - | 0.0271 | - | 0.0271 |
| 580999 | - | 0.1020 | - | 0.1020 |
| 580001 | / | / | - | 0.0429 |
| 580002 | / | / | - | 0.9690 |
| 580003 | / | / | + | 0.3501 |
| 580004 | / | / | - | 0.0695 |
| 580005 | / | / | - | 0.0003 |
| 580006 | / | / | + | 0.9902 |
| 580008 | / | / | - | <.0001 |
| Bubble Increased at 5% Lever | 0 | | 0 | |
| Bubble Decreased at 5% Lever | 3 | | 6 | |
| Bubble Unchanged at 5% Lever | 7 | | 11 | |

## Table 8. Regression Analysis

This table shows the regression results with magnitude of price premium as the dependent variable. Event of maximum cumulative new issuance is a dummy variable that takes a value of one for days after the maximum cumulative new issuance. Ratio of maximum cumulative new issuance is defined as the ratio of the maximum shares of net new issuance to the shares of initial issuance. Put warrant is a dummy variable that takes a value of one for put warrants. Theory price is the intrinsic warrant value calculated by Black-Scholes formula. Time to maturity is calculated using the number of calendar days to expiration of the warrant. State-owned stock is a dummy variable that takes a value of one if the company is a state-owned enterprise. (T-statistics are in parentheses.)

| Variable | Reg 1: Put Warrants | Reg2: Put and Call Warrants |
|---|---|---|
| Intercept | -1.4753 (-5.27) *** | -0.4618 (-1.85) * |
| Event of max cum. new issuance | -0.1461 (-2.11) ** | -0.1865 (-2.96)*** |
| Raito of max cum. new issuance | -0.0447 (-1.24) | 0.0652 (2.85)*** |
| Put warrant | / | -0.0168 (-0.15) |
| Theory price | -1.8659 (-2.43) ** | 0.0409 (3.42) *** |
| Time to maturity | 0.0125 (5.69) *** | 0.0060 (9.8) *** |
| Log (market cap. Of warrants) | -0.4051 (-3.57) *** | -0.6298 (-6.96) *** |
| Log (trading vol. of warrants) | 0.0828 (1.70) * | 0.1537 (3.01) *** |
| Log (market cap. of stock) | 0.5291 (7.12) *** | 0.3685 (5.44) *** |
| Log (trading vol. of stock) | -0.3818 (-6.61) *** | -0.1570 (-3.15) *** |
| State-owned stock | 0.0635 (0.54) | -0.0420 (-0.46) |
| # of Observations | 99 | 169 |
| Adj. R-Square | 0.6782 | 0.4907 |

***, **, * indicate significantly different from zero at the 1, 5, and 10 percent level, respectively.