Trading Restrictions and Over-valuation of Covered Warrants in China

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Ming-Hua Liu*
Faculty of Business & Law
Auckland University of Technology
Private Bag 92006
Auckland, 1142, New Zealand

Email: mliu@aut.ac.nz

Nanda K Rangan
Department of Finance, Insurance & Real Estate
School of Business
Virginia Commonwealth University
Snead Hall, 301 W. Main Street, Box 844000
Richmond, VA 23284-4000, USA

Email: nkrangan@vcu.edu

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* *Corresponding author*

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This paper examines the valuation of covered warrants traded in China and finds that the implied volatility is consistently higher than the realized volatility across maturities, resulting in huge overvaluation across maturities. The results appear attributable to regulatory issues such as restrictions on the short-selling of warrants, differential trading rules for stocks and warrants, high leverage and low trading costs, and a market dominated by retail investors.

1. Introduction

In 1995, the Chinese government banned all financial derivatives due to concerns of excessive speculation. In August 2005, nearly a decade later, the Chinese government re-launched the trading of covered warrants as part of a plan to compensate equity investors for allowing non-tradable shares to be traded on the stock exchange. As of June 2008, there were only 17 outstanding warrants. However, despite its small size and late start, China's warrant market has been very popular. It is now one of the largest in the world when measured in terms of trading volume. In 2006, China's warrant market was the second most active in the world, with a trading value of over USD240 billion versus Germany's USD286 billion, according to statistics by the World Federation of Exchanges. Trading in warrants in China can sometimes account for as much as 50% (and on one occasion, 80%) of the combined turnover of the Shenzhen and Shanghai exchanges.[1]

Chinese warrants are unique in some ways. They differ from traditional equity warrants issued by companies. Traditional equity warrants are call options. New shares are issued by the company when they are exercised, leading to a dilution of earnings and

[1] Covered warrants have become very popular among retail investors in Europe and Asia. For example, in Hong Kong, there are over 2,000 outstanding warrants. Warrant trading accounts for over 20% of the exchange's total trading volume. See Table 1.

control. In the case of warrants in China, the warrants can be calls or puts. Most of the warrants issued in China are connected with the floatation of non-tradable shares, as mentioned above. The rest are linked with convertible bonds (see Zhu, 2007). When the call options are exercised by investors, non-tradable shares are issued by the Chinese company, leaving the total number of outstanding shares unchanged. Hence, there is no dilution of earnings. In this aspect, the warrants in China are similar to covered warrants in Europe and Asia. However, covered warrants in Europe and Asia are issued by third parties such as banks, whereas in China, most warrants are issued by companies.

In this paper, we examine the valuation of covered warrants in China. The Chinese equity market is well known for its volatility and excessive speculation. We address three specific issues. Does speculation still rule the Chinese warrant market, as was true in the mid 1990s before warrants were banned? Why are warrants so popular in China? Finally, are covered warrants mispriced?

The study of covered warrants in China is of particular interest for several reasons. First, the warrant market in China, as in other countries such as Hong Kong and Singapore, is dominated by retail investors. Retail investors appear to have very little knowledge of warrants, but are attracted by the leverage they afford, their low trading costs and their trading flexibility[2]. Warrants are also attractive because margin trading is very limited in China. It is almost impossible to obtain personal loans from commercial banks or other financial institutions for equity investment. Furthermore, retail investors in China tend to ignore the fundamentals of listed companies. Instead, they simply speculate on the low quality of financial disclosures (Kang et al., 2002). Trading many times a day, they speculate on the directional change in the price of the underlying stock rather than

[2] According to a survey conducted by Guotaijunan Securities Ltd (2005)

its volatility. Anecdotal evidence indicates that investors clearly lack the understanding that volatility can affect the market value of covered warrants.

Implied volatility is regarded as the best predictor of future volatility, as demonstrated by institutional option traders (Canina and Figlewski, 1993; Day and Lewis 1992; Jorion 1995). Hence, we examine the role of implied volatility in the fast-growing Chinese covered warrant market to see whether it offers any new insights, given the fact that markets are dominated by retail investors, rather than institutional investors.

Second, in contrast to other types of option trading, such as the trading of currency options or interest rate options in the interbank market, short-selling in covered warrants is not allowed for fear that the short-selling party will not be able to cover its short positions. The prohibition of short-selling is not uncommon in other markets, such as Australia, Hong Kong and Singapore. However, it is particularly severe in China. In other countries, although short-selling is not allowed, investors can still short-sell if they cover their position within the same day through so-called "contra trading". If they do not buy back within the same day, the exchange can execute a buy-in transaction later, which subjects the short-sellers to price risks.

However, in China, one must pay first (usually at a bank counter or online) before an order to buy stocks or warrants can be executed. To sell stocks, one must wait at least one day or longer after the purchase, but warrants can be sold within the same day as long as the assets are in one's portfolio. The ability to take a profit or cut a loss within the same day can have significant implications for the valuation of covered warrants. The inability to short-sell can have serious implications for the overvaluation and efficiency of covered warrants and, hence, the usefulness of implied volatility.

Third, covered warrants are widely regarded as a success story in China and other countries. Due to their popularity among retail investors, trading volume has soared. However, whether these products are suitable for unsophisticated retail investors needs further examination, as options are complicated instruments. To make money in trading warrants, one needs to control not only the directional risk (i.e., delta), but other types of market risks, such as gamma, vega, theta and rho. As covered warrants have a maturity date, the call buyer needs to ensure that the underlying price not only goes up, but goes up fast enough (in order to finish in the money upon maturity). In other words, both volatility and the price of the underlying stock can affect the profit and loss of the portfolio. It is inappropriate to view covered warrants as pure substitutes of the underlying securities, as many retail investors do. Our study has implications for investor education in option trading.

Finally, while covered warrants are very popular in Europe, Asia and Australia, they do not exist in the United States. Very few studies have examined the pricing and valuation of covered warrants, although some studies have analyzed the impact of covered warrant trading on the underlying stocks (Chan and Wei, 2001; Draper, Mak and Tang, 2001). Chan and Pinder (2000) examined the covered warrant market in Australia. They found that covered warrants were overpriced relative to options and attributed the overpricing to differences in transaction costs. Horst and Veld (2008) examined the pricing of call warrants and bank-issued exchange-traded call options in the Netherlands. They found that call warrants are overpriced relative to exchange options and attributed the overpricing to a combination of active financial marketing by banks and a framing effect.

Our results show that European-style covered warrants in China were significantly overvalued over the period of 2005-2008. The implied volatility is much higher than the realized volatility and has no relationship with future volatility, implying that the Chinese markets are very different from other markets in that the implied volatility is not useful in predicting future volatility. These results may be driven by the fact that the covered warrant market in China is dominated by retail investors, who may lack knowledge and skill in option trading. Furthermore, the warrants are popular due to low trading costs and high trading flexibility. As a result, the covered warrant market in China is largely inefficient. The huge demand for covered warrants drives up prices, and short-selling restrictions make arbitrage impossible.

The remainder of the paper is organized as follows. Section 2 discusses the institutional details of the Chinese warrant market. Section 3 outlines the data and research methodology. In Section 4, we discuss the empirical results. Section 5 provides robustness tests, and Section 6 concludes the study.

2. Background of the Chinese warrant market

The first Chinese warrant was introduced in 1992. Before trading was banned in June 1996 due to excessive speculation, only a few companies had issued them. On August 22, 2005, warrant trading was re-launched with the call warrant issued by Bao Steel. The issuance was part of the reform plan to float the non-tradable shares in state-owned enterprises (SOEs).[3], The first put warrant was issued in August 2006. As of June

[3] Prior to the 2005 reform, the shares of listed state-owned enterprises (SOEs) and their shares were divided into two components: tradable and non-tradable. The tradable shares account for about one-third of the total outstanding shares, and the non-tradable shares account for the remaining two-thirds. As a result, the equity market was very illiquid. One of the major problems facing regulators had been how to float the non-

2008, there were only 17 outstanding warrants. Although the number of warrants in China is very small, the trading value can sometimes exceed USD 15 billion per day, accounting for over 50% of the total trading value, where there are over 1,000 firms listed in the Shanghai and Shenzhen exchanges. Although there are European-, American- and Bermudan-style warrants in China, we focus on European call and put warrants, as these can relatively easily be valued by using the Black-Scholes option pricing model.

Chinese warrants are very popular because their trading mechanism differs considerably from that of equities in the stock market. First, trading costs in the warrant market are lower. The minimum price change for the warrant is 0.001 RMB, whereas the minimum price change for stock is 0.01 RMB. While the commissions for both stock trading and warrant trading are similar, the stamp duty differs significantly. Stamp duty is imposed on the buying and selling of stocks, but not on warrants (buying or selling). The stamp duty for equity trading has ranged from 0.1% to 0.6% of the trading value over the past few years in China.

The stamp duty in China is much higher than that of other countries and is sometimes used as a tool to prevent excessive speculation or to stimulate the stock market. For example, in May 1997, it was raised from 0.3% to 0.5% of the trading value in order to curb wild speculation. Such changes in the stamp duty can have a major impact on warrant trading. For example, on May 30, 2007, the stamp duty for equity trading was increased from 0.1% to 0.3%, and the trading value of the warrants increased significantly, as they became much cheaper to trade.

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tradable shares without depressing the stock market. Two previous attempts to resolve this problem had failed (see Bortolotti and Beltratti, 2006). In 2005, it was decided that bonus shares and/or warrants would be given to minority shareholders as a compensation for allowing the non-tradable shares to be floated.

Combined with the leverage offered by warrants, their overall trading costs are much lower. For example, the stamp duty for buying or selling stocks between May 30, 2007, and April 24, 2008, was 0.3% of the trading value, but was zero for warrants. A round-trip transaction (a buy followed by a sell) for stocks would cost 0.6% more. Assuming an effective leverage ratio of 3 to 5 for warrants, the difference in stamp duty alone would be 1.8% to 3% of the trading value for the same amount of exposure to equities.

Furthermore, equity trading in the Chinese market has adopted the so-called "T+1" system, whereas the warrants come under the "T+0" system. Under the "T+1" system, an investor cannot buy and sell his or her shares on the same day. One must wait at least one trading day before being allowed to sell. Under the "T+0" system, an investor can buy and sell many times on the same day. The "T+1" system was introduced to prevent excessive speculation in the stock market (a result of the previous "T+0" system). When the warrants were re-launched in 2005, the "T+1" system was regarded as inappropriate for warrants, as warrants are much more volatile and investors would not have been able to cut their exposure. Furthermore, due to the time decay effect, warrants are wasting assets, especially short-dated warrants. As a result, warrants are very popular among day-traders. According to a survey conducted by a brokerage firm (Guotaijunan Securities Ltd) in Shanghai in 2005, 76.7% of investors traded warrants more than once a day and 27.1% of investors traded warrants between 5 and 10 times per day. On average, they traded warrants 7.08 times per day. The survey also shows that most of the warrant investors are retail investors, although it did not give an exact number.

Finally, the daily price change limits are different. For equity, the maximum price change per day is 10%. For warrants, the absolute maximum price change is 125% of the absolute maximum price for equity. On a relative basis, this can be over 100% of the warrant's price. In other words, the potential for a warrant price change on a daily basis is huge. For example, the price of one put warrant (code: 038008, a Bermudan option not included in our sample) increased by 192% (from 0.84 to 2.45) in one day (May 30, 2007). It went up by over 623% over a three-day period. Two weeks later, the price dropped from 4.98 to 0.11 over the final two weeks of trading (see Figure 1). Despite the fact that the option finished out of the money and trading had stopped, the warrant price did not go to zero, as the option's maturity was one week away and some investors were betting that the option would still finish in the money. In another case, the price of a call warrant issued by Bao Steel (code: 580000) dropped by 83% on the last trading day to finish at 0.031 RMB (see Figure 1).

{INSERT FIGURE 1 HERE}

The popularity of warrants in China has resulted in significant overvaluation, leading to bubbles. Misprices are very common. For example, in November 2005, two warrants were issued by Wuhan Iron & Steel Co. One was a call warrant (code: 580001), and the other was a put warrant (code: 580999). Both had the same maturity, but with different strike prices. Based on option pricing theory, the prices of the two options should move in opposite directions, as calls are positively related to the underlying stock price and puts are negatively related. However, in reality, the market prices moved together, and the correlation coefficient between them was +73% (see Figure 2). The

prices did not diverge until the final ten trading days or so. If we ignore the final trading days, the correlation coefficient would be +84%. According to our calculation, the theoretic correlation coefficient should be –4% based on the Black-Scholes option pricing model.

{INSERT FIGURE 2 HERE}

Recognizing the rampant speculation and overvaluation, the Chinese government attempted to address the issue. They believed that the overvaluation was due to an imbalance between supply and demand.[4] As an experiment, in November 2005, the Shanghai Securities Exchange allowed select brokerage firms to sell additional put options and covered call options (with identical terms and codes) on the stock of Wuhan Iron & Steel Co., in order to increase supply and thus curb irrational speculation.[5] Under the above plan, ten brokerage firms were allowed to sell 1.127 billion put warrants, increasing the supply to 1.601 billion. This resulted in a halt in warrant trading for two consecutive days, as prices dropped to their maximum daily limits.

Since 2006, qualified brokerage firms have been allowed to issue a limited amount of put and/or call warrants on an ad hoc basis, subject to approval by the exchanges. However, the issuers were not allowed to trade those warrants on the secondary market. The measure succeeded in curbing the rampant speculation to a certain extent, but was not popular among the investors. Retail investors were not allowed to write put or call

[4] During the period of August 2005 to November 2005, there was only one outstanding warrant, which was issued by Bao Steel, code: 580000.

[5] In the case of put warrants written by brokerage firms, a cash deposit was required. In the case of call warrants, the issuer could only write covered calls. Naked calls were not allowed. The issuer could not change the maturity date or the strike price of the warrants.

warrants (i.e., short-sell), and when brokerage firms issued the warrants, no prior disclosure was made to the investors until the day the warrants started trading under the existing warrant codes, maturity dates and strike prices.

Retail investors have challenged both the fairness and legality of the measures taken by the exchanges, where these issues have not yet been resolved. The exchanges and financial institutions are also very interested in further developing the covered warrant market in China, where financial institutions can sell puts or calls of any listed company and not just existing warrants issued by the few big listed companies. However, opposition from investors in China remains an obstacle for the further development of the warrant market in China.

3. Data and Methodology

Covered warrants are highly popular among retail investors in Europe and Asia. We provide details on the number of covered warrants listed and their trading in the Asia-Pacific region and the growth of the warrant market in China over the period of 2005-2008 in Table 1.

(Insert Table 1 here)

The following subsections describe our data and methodology.

3.1 Data

The daily data were downloaded from the CSMAR (China Stock Market and Accounting Research) database provided by GTA (Guo Tai An) IT Ltd. The data include the closing prices for European call and put warrants, the daily closing prices of the underlying stocks, the daily risk-free interest rate of various maturities and other details

(expiration date, strike price and exercise ratio). Only the expired covered warrants of individual stocks are included in the sample, given the need to calculate the actual realized volatility as well as the implied volatility. We include only European warrants, as previously stated. Our final dataset consists of 24 European covered warrants covering the period of August 2005 to June 2008, with a total of about 6,000 observations. Among the 24 warrants, 12 are calls and 12 are puts.

3.2. Methodology

We first estimate three different types of volatility for each warrant on a daily basis: realized volatility, implied volatility and historical volatility. We examine the degree of mispricing by comparing the implied and realized volatilities and then comparing the market price with the model price.

To examine the relationship between implied and realized volatilities, we use both time-series and cross-sectional regression analysis. We rely on time-series regression to analyze the relationship between realized volatility and implied volatility for each warrant. Next, using the time-series data on volatility, we use cross-sectional regression analysis to examine the relationship between realized volatility and implied volatility for standard maturities: 1, 3, 6 and 12 months. Time-series regression analysis allows us to examine valuation over the entire life of each warrant, whereas the cross-sectional regression analysis allows us to examine how valuation varies across maturities.

Realized volatility is obtained by calculating the annualized daily standard deviation of daily returns over the life of the covered warrants. The daily standard deviation is then annualized using a multiplier of the square root of the number of trading days (252) per year. We calculate both the implied volatility and the model price for each of the 24

covered warrants on a daily basis during the period of August 2005 to June 2008 using the Black-Scholes option pricing model.

Following Jorion (1995) and Covrig and Low (2003), we apply the following model to investigate the relationship between realized volatility and implied volatility:

$$\sigma_{RV,i} = \alpha_0 + \alpha_1 \sigma_{IV,i} + \varepsilon_i \quad (1)$$

where $\sigma_{RV,i}$ is the daily realized volatility for warrant *i*, $\sigma_{IV,i}$ is the daily implied volatility derived from the Black–Scholes model for warrant *i*, and ε_i is the error term for warrant *i*. We estimate this time-series regression model for each of the 24 warrants in our sample.

To further examine the relationship between realized volatility and implied volatility, we employ the following cross-sectional regression model:

$$\sigma_{RV,t,T} = \alpha_0 + \alpha_1 \sigma_{IV,t,T} + \varepsilon_t \quad (2)$$

where $\sigma_{RV,t,T}$ is the realized volatility over the period of t to t + T, $\sigma_{IV,t,T}$ is the implied volatility measured on day t for a warrant that expires on day t + T, and ε_t is the error term. Our dataset contains four different forecasting horizons: 1, 3, 6 and 12 months. Only the volatilities in the same forecasting horizon are regressed together.

If the implied volatility has any potential information about the future volatility, α_1 should be non-zero and positive. Furthermore, if the implied volatility is unbiased, the intercept, α_0, should be zero and α_1 should equal unity.

4. Empirical Results

Table 2 provides the average implied volatility and the average realized volatility for each of the 24 warrants in our sample as well as for the entire sample. For all warrants in

our sample, the results show that the implied volatility is significantly higher than the realized volatility. The implied volatility ranges from 62.8% to 365%, whereas the realized volatility ranges from 22.6% to 86.5%, similar to the range of historical volatility.

While the average realized volatility is about 52% for the entire sample, the average implied volatility is 148%, indicating that, on average, warrants are significantly overvalued as volatility and that option values are positively related. Furthermore, except for two, all of the warrants have a volatility of well over 100% per year.

[INSERT TABLE 2 HERE]

To demonstrate the degree of overvaluation, we calculate the model price using the Black-Scholes method and compare it to the market price. The results are reported in Table 3. Aside from two warrants that are slightly underpriced, all of the warrants are overpriced, ranging from 8% to over 800%. The average overpricing for the entire sample is 155%. Puts are more overpriced, partly reflecting the fact that they are the only equity derivative able to serve as a hedge for a downward market trend.

[INSERT TABLE 3 HERE]

To further examine the relationship between implied volatility and realized volatility, we estimate the simple regression model in Equation (1) and report the results in Table 4. When the realized volatility is regressed against the implied volatility, all of the intercepts are significantly positive, and the coefficients of implied volatility (α_1) are nearly zero for all of the warrants. The results show that the warrants are so mispriced

that the implied volatility has virtually no predictive power for the future volatility. Nine of the 24 warrants even have a negative relationship.

The results are in sharp contrast to studies that have shown that implied volatility from options dominated by institutional traders is the best predictor of future volatility (Canina and Figlewski, 1993; Day and Lewis 1992; Jorion 1995). The results are consistent with our hypothesis that, in option markets dominated by retail investors, implied volatility does not contain much information regarding future volatility and options are significantly mispriced. In the case of the Chinese warrant market, the implied volatility provides no information for the future volatility, let alone providing an unbiased forecast of it.

[INSERT TABLE 4 HERE]

Our findings indicate that, unlike other option markets, the covered warrant markets are dominated by retail investors attracted by the high leverage, high upside potential (due to a larger daily price change limit), low transaction costs and trading flexibility offered by covered warrants. With little knowledge or expertise of option trading, they tend to use covered warrants as a substitute for the underlying stocks and speculate on the direction of stock prices rather than volatility. They also do so many times per day (flipping). As a result, covered warrant markets are hugely overvalued in China, and short-selling restrictions make arbitrage impossible.

5. Robustness Tests

As a robustness test, we examine whether overvaluation is consistent across the different maturities of covered warrants. We calculate the implied and realized volatilities for standard maturities (1, 3, 6 and 12 months) and then estimate the regression model in Equation 2. Table 5 details the descriptive statistics of realized volatility and implied volatility of the selected standard maturities for the entire sample.

Similar to the results reported in Table 2, the results show that the average implied volatility is significantly higher than the realized volatility. This is true for both the mean and the median, indicating that both short-term (1-month) as well as long-term (12-month) warrants are significantly overvalued.

[INSERT TABLE 5 HERE]

The regression results for Equation 2 are reported in Table 6. For each of the four standard maturities, the coefficient for implied volatility is not significantly different from zero. In other words, the implied volatility is not related to the realized volatility, indicating that the warrants are systematically mispriced. This is consistent with the results reported in Table 3.

[INSERT TABLE 6 HERE]

6. Conclusions

In this study, we examined the valuation of covered warrants traded in China. Our results show that the implied volatility is significantly higher than the realized volatility for all warrants. Covered warrants are significantly overvalued over the sampling period.

In fact, the warrants are so overvalued that the implied volatility provides no information for the future volatility. This is true for short-term (1-month) as well as long-term (12-month) volatility.

The results can be attributed to the unique trading restrictions and other institutional features found in China. Warrants are hugely popular because they are more flexible than the underlying stocks for short-term speculative trading. They also offer more leverage, which is valuable because funding opportunities and margin financing are very limited for retail investors in China. Combined with lower trading costs and higher daily price fluctuation limits, warrants have become a very attractive tool for investors to bet on the price directions of stocks, leading to significant overvaluation. Overvaluation persists due to severe short-selling restrictions.

Currently, warrants are the only form of financial derivatives in China, and the Chinese warrant market is believed to have a large potential. However, our results show that the market is inefficient and that speculation still rules. In order to restore efficiency, regulators need to remove some of the trading restrictions, such as by allowing stock investors to sell stocks within the same day of purchase. Margin trading could be introduced, and short-selling restrictions should be removed. The regulatory authorities should also increase the number and amount of warrants in order to meet an untapped demand in the market. Furthermore, our study highlights the need for investor education in order for investors to better understand the risk and return associated with investing in covered warrants and other types of derivatives.

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Table 1
Covered warrants in the Asia-Pacific region.

This table shows the number of covered warrants listed and the trading value. In 2006, while the number of covered warrants in China is the smallest in the region, the trading value is the highest. The statistics for 2007 are not available.

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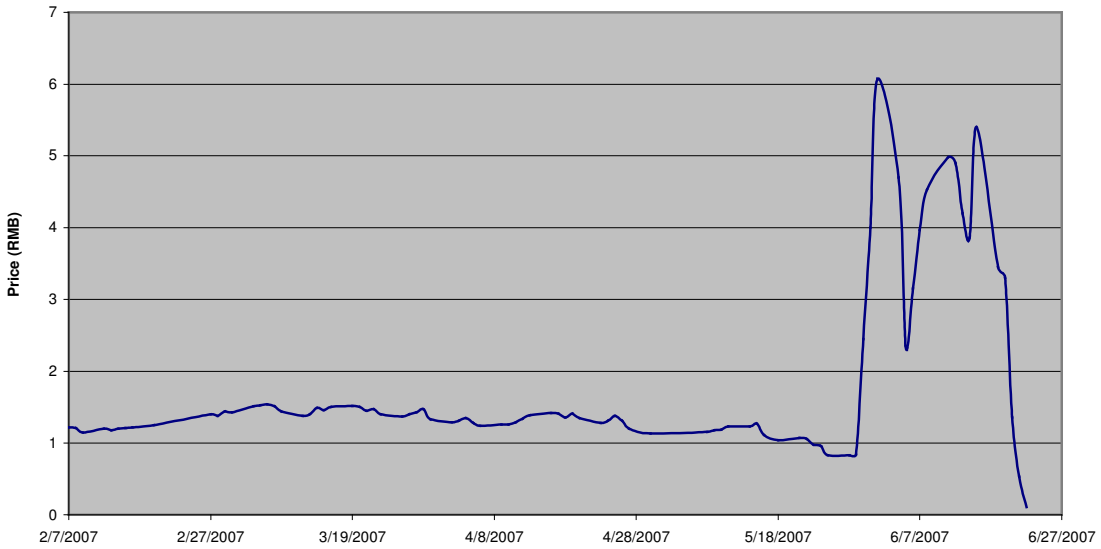
Exchange	Number of covered warrants listed (at year end)			Trading value (USD millions)		
	2005	2006	2007	2005	2006	2007
Australia	2,447	3,091	4,028	4,985	7,311	17,428
China	4	26	N.A.	21,548	243,900	N.A.
Hong Kong	1,304	1,959	4,614	110,168	230,411	610,380
Korea	72	1,387	1,646	41	43,689	73,039
Malaysia	12	33	120	277	934	3,843
New Zealand	21	36	35	45	57	80
Singapore	455	521	883	6,521	9,156	19,594
Taiwan	540	694	2,085	4,424	5,388	7,717

Source: Annual Report, World Federation of Exchanges (2006, 2007) and South China Morning Post (4 January 2007).

Figure 1
Daily price of select warrants
Panel A shows the daily price movement of a Bermudan put warrant (not included in our sample), and Panel B shows the daily price movement of a call warrant issued by Bao Steel, the first warrant to be launched in 2005 when covered warrants were revived by the government. Both warrants crashed in the final trading days, finishing out of the money.

Panel A: Put warrant 038008



Panel B: Call warrant 580000 (the 1st warrant launched in 2005)

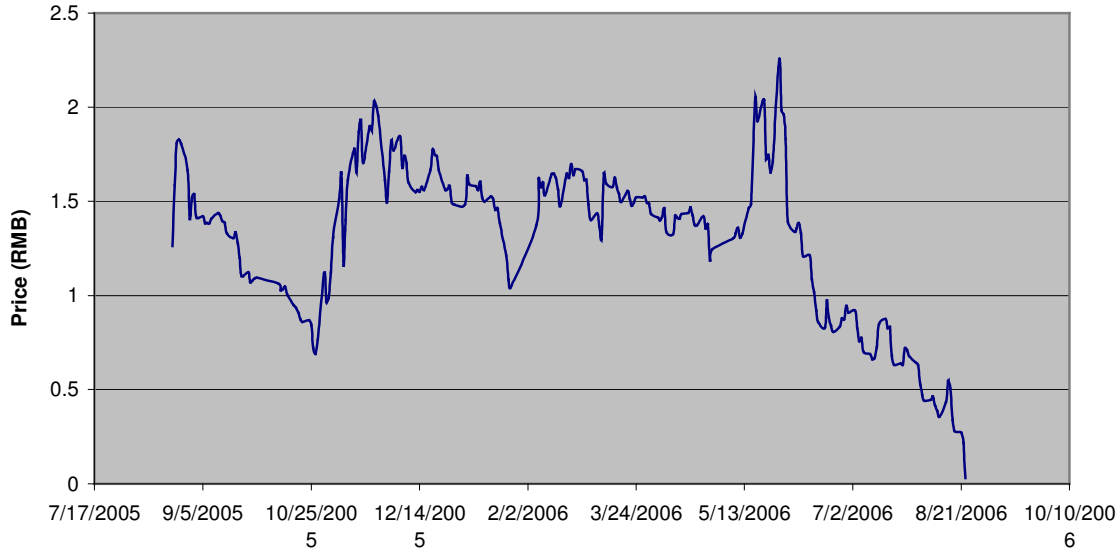
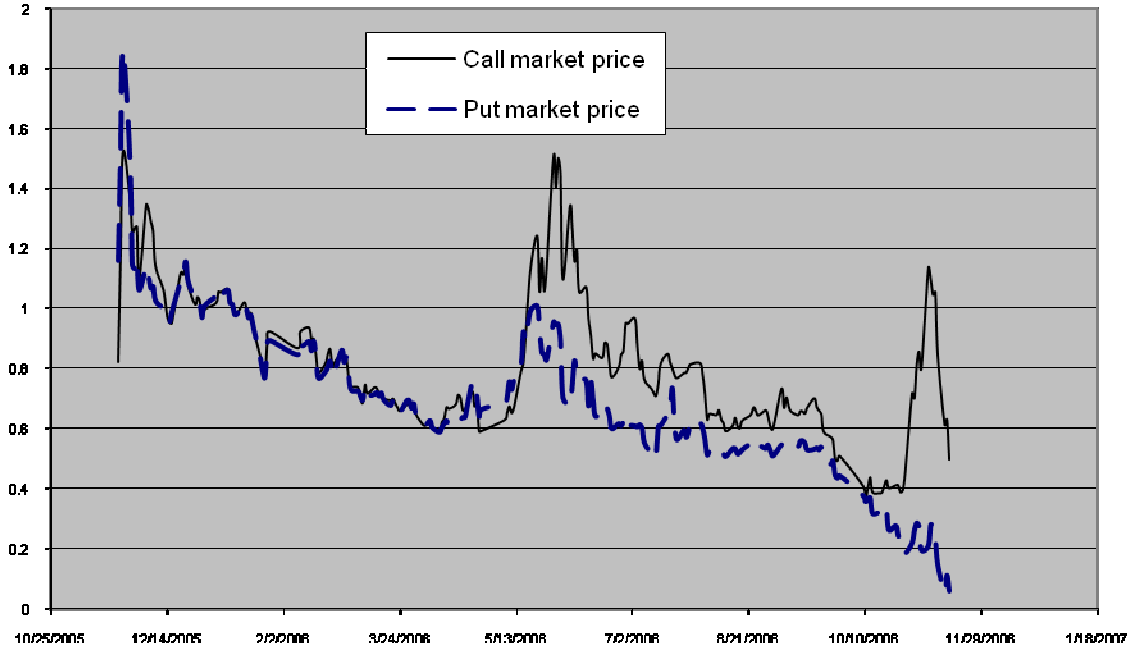


Figure 2:
Daily price of two warrants issued by Wuhan Iron & Steel Co
Panel A shows the daily market price movement of a call warrant versus a put warrant issued by the same company. Panel B shows the Black-Scholes model price movement of the two warrants. Theoretically, the prices should move in opposite directions. In reality, they moved in the same direction until the final trading days, indicating mispricing.

Panel A: Daily market price



Panel B: Daily model price

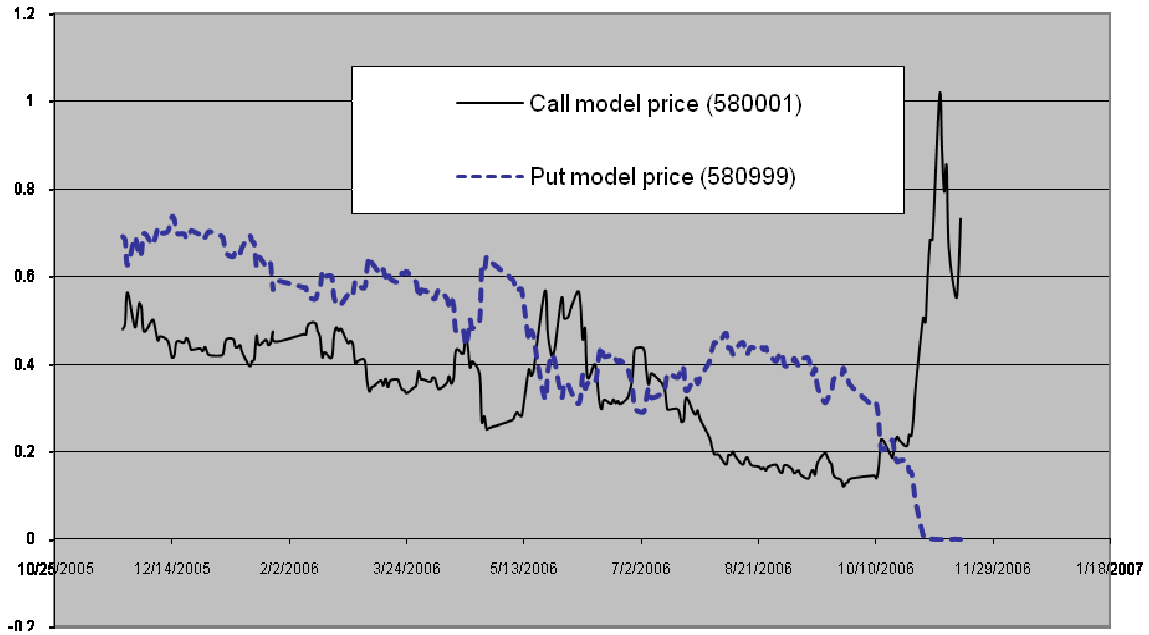


Table 2:
Average volatility (historical, implied and realized) of Chinese warrants
For a warrant with a remaining maturity of T years on day t, the historical volatility is calculated as the standard deviation of the daily returns over the period t-T. Realized volatility is calculated as the standard deviation of the daily returns over the period t+T. Implied volatility is calculated using the Black-Scholes pricing model. All volatilities are calculated on a daily basis and then annualized. The results show that the implied volatilities are, on average, three times higher than the realized volatility for all warrants, indicating that the warrants are significantly overvalued.

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Warrant Code	Warrant Acronym	Warrant Type	Historical Volatility	Implied Volatility	Realised Volatility	Maturity	Expiry date
30001	AGJTC1	Call	0.382	1.602	0.394	1	5-Dec-2006
58000	BGJTB1	Call	0.267	1.272	0.226	1.02	30-Aug-06
58001	WGJTB1	Call	0.435	1.157	0.385	1	22-Nov-06
58002	BGJTB1	Call	0.721	1.467	0.561	1	30-Mar-07
58003	HGJTB1	Call	0.498	1.151	0.545	1	04-Apr-07
58004	SCJTB1	Call	0.519	1.793	0.432	1	23-Apr-07
58005	WHHXB1	Call	0.579	3.605	0.515	1	26-Apr-07
58006	YGQCB1	Call	0.582	1.773	0.623	1	21-May-07
58007	CDCWB1	Call	0.291	1.212	0.449	1	24-May-07
58008	GDJTB1	Call	0.527	1.663	0.558	1	04-Sep-07
58009	YLCWB1	Call	0.491	1.496	0.477	1	14-Nov-07
58011	ZHCWB1	Call	0.558	1.629	0.674	1	17-Dec-07
580989	NHJTP1	Put	0.668	1.437	0.835	1	20-Jun-08
580990	MTJCP1	Put	0.896	1.002	0.455	1	29-May-07
580991	HEJTP1	Put	0.312	1.424	0.571	0.98	16-May-07
580992	YGQCP1	Put	0.582	1.659	0.624	1	21-May-07
580993	WHHXP1	Put	0.579	1.714	0.515	1	26-Apr-07
580994	YSCTP1	Put	0.424	1.090	0.389	0.82	12-Feb-07
580995	BGJTP1	Put	0.721	1.369	0.560	1	30-Mar-07
580996	HCJTP1	Put	0.408	0.627	0.475	1	06-Mar-07
580997	ZXCMP1	Put	0.395	1.406	0.507	1.5	31-Aug-07
580999	WGJTP1	Put	0.435	0.799	0.384	1	22-Nov-06
38001	GFPGP1	Put	0.715	1.634	0.556	1.41	08-May-07
38003	HLJTP1	Put	0.432	1.579	0.566	2	29-Feb-08
Average for calls			0.487	1.652	0.487		
Average for puts			0.547	1.312	0.536		
Average for all			0.517	1.482	0.511		

Notes: all warrants are European style.

Table 3:
Pricing (average model price versus average market price) of Chinese warrants
The model price is calculated using the Black-Scholes pricing model. The premium is calculated as (market price – model price) / market price. Prices are in RMB (1 USD = 6.90 RMB in 2007). The results show that all but two warrants are overpriced, with an average premium of 155% for the entire sample.

Warrant Code	Warrant Acronym	Warrant Type	Model Price	Market Price	Premium
30001	AGJTC1	Call	2.17	3.02	39%
58000	BGJTB1	Call	0.25	1.29	415%
58001	WGJTB1	Call	0.36	0.81	125%
58002	BGJTB1	Call	1.14	1.39	22%
58003	HGJTB1	Call	1.61	1.90	18%
58004	SCJTB1	Call	1.69	2.81	67%
58005	WHHXB1	Call	10.89	19.32	77%
58006	YGQCB1	Call	5.63	6.34	13%
58007	CDCWB1	Call	3.62	4.56	26%
58008	GDJTB1	Call	5.58	6.37	14%
58009	YLCWB1	Call	21.56	21.33	-1%
58011	ZHCWB1	Call	10.07	10.88	8%
580989	NHJTP1	Put	0.11	1.02	854%
580990	MTJCP1	Put	0.68	1.03	52%
580991	HEJTP1	Put	0.12	0.73	511%
580992	YGQCP1	Put	0.19	0.69	267%
580993	WHHXP1	Put	0.21	1.49	599%
580994	YSCTP1	Put	0.39	1.00	156%
580995	BGJTP1	Put	0.46	0.57	24%
580996	HCJTP1	Put	1.28	1.17	-8%
580997	ZXCMP1	Put	0.18	0.52	195%
580999	WGJTP1	Put	0.46	0.69	52%
38001	GFPGP1	Put	0.78	1.23	58%
38003	HLJTP1	Put	0.67	1.65	144%
Average for calls			5.38	6.67	69%
Average for puts			0.46	0.98	242%
Average for all			2.92	3.83	155%

Table 4:
Regression analysis of the relationship between realized volatility and implied volatility for individual warrants.

For each of the 24 warrants in our sample, we run the following simple time-series regression to investigate the relationship between realized volatility and implied volatility:

$$\sigma_{RV,i} = \alpha_0 + \alpha_1 \sigma_{IV,i} + \varepsilon_i$$

Where $\sigma_{RV,i}$ is the daily realized volatility for warrant *i*, $\sigma_{IV,i}$ is the daily implied volatility derived from the Black–Scholes model for warrant *i* and ε_i is the error term for warrant *i*.

Warrant code	Warrant Acronym	Warrant Type	Constant	T-Value	Slope	T-Value	R-Square
30001	AGJTC1	Call	0.43	44.26*	-0.02	-3.56*	0.05
58000	BGJTB1	Call	0.20	16.52*	0.02	2.10**	0.02
58001	WGJTB1	Call	0.32	16.04*	0.06	3.69*	0.06
58002	BGJTB1	Call	0.54	29.95*	0.01	0.91	0.00
58003	HGJTB1	Call	0.65	49.35*	-0.09	-8.85*	0.25
58004	SCJTB1	Call	0.51	42.87*	-0.04	-6.84*	0.17
58005	WHHXB1	Call	0.55	89.28*	-0.01	-7.41*	0.19
58006	YGQCB1	Call	0.55	51.08*	0.04	6.79*	0.17
58007	CDCWB1	Call	0.53	48.50*	-0.06	-7.21*	0.18
58008	GDJTB1	Call	0.62	53.40*	-0.04	-5.92*	0.14
58009	YLCWB1	Call	0.48	127.85*	0.00	-2.11*	0.02
58011	ZHCWB1	Call	0.73	57.35*	-0.03	-4.26*	0.07
580989	NHJTP1	Put	0.77	50.52*	0.04	4.33*	0.08
580990	MTJCP1	Put	0.45	97.74*	0.01	1.26	0.01
580991	HEJTP1	Put	0.52	88.69*	0.03	9.84*	0.30
580992	YGQCP1	Put	0.56	70.80*	0.04	10.11*	0.31
580993	WHHXP1	Put	0.56	85.25*	-0.03	-8.00*	0.22
580994	YSCTP1	Put	0.31	49.69*	0.08	14.66*	0.53
580995	BGJTP1	Put	0.57	72.16*	-0.01	-1.33	0.01
580996	HCJTP1	Put	0.37	89.80*	0.17	33.43*	0.83
580997	ZXCMP1	Put	0.49	170.58*	0.02	10.67*	0.24
580999	WGJTP1	Put	0.30	19.61*	0.11	6.13*	0.14
38001	GFPGP1	Put	0.52	78.92*	0.02	6.24*	0.11
38003	HLJTP1	Put	0.54	136.51*	0.02	10.70*	0.21

Notes: * significant at the 1% level. ** significant at the 5% level.

Table 5:
Descriptive statistics for realized volatility (RV) and implied volatility (IV)

This table summarizes the mean, median, standard deviation and number of observations of realized volatility (RV) and implied volatility (IV) for warrants with 1-month (1M), 3-month (3M), 6-month (6M) and 12-month (12M) maturity. The sampling period is from August 2005 to June 2008, and the number of warrants is 24. Both the mean and median for implied volatilities are much higher than those of realized volatility, indicating that the warrants are overvalued.

	Variable	Mean	Median	Std. D.	Max.	Min.
1M	RV	54%	55%	17%	83%	14%
	IV	305%	216%	224%	1224%	75%
3M	RV	55%	57%	15%	94%	20%
	IV	213%	191%	177%	1011%	70%
6M	RV	52%	53%	12%	79%	26%
	IV	142%	121%	85%	433%	33%
12M	RV	50%	50%	13%	82%	22%
	IV	93%	91%	35%	149%	21%

Table 6
Cross-sectional regression analysis of the relationship between realized volatility and implied volatility for standard maturities

This table reports the regression results of the following equation:

$$\sigma_{RV,t,T} = \alpha_0 + \alpha_1 \sigma_{IV,t,T} + \varepsilon_t$$

where $\sigma_{RV,t,T}$ is the realized volatility over the period t to t + T and $\sigma_{IV,t,T}$ is the volatility forecast derived from the Black–Scholes model measured on day t for a warrant that expires on t + T, taken as the implied volatility. The results show that the implied volatilities are not related to realized volatilities, indicating that warrants were severely mispriced and that the implied volatility contain no information for the future volatilities.

	Intercept	Slope	R-Square
1 Month Vol	0.55 (8.90)*	0.00 (-0.10)	0.00
3 Months Vol	0.54 (10.89)*	0.01 (0.45)	0.01
6 Months Vol	0.46 (9.81)*	0.04 (1.44)	0.09
1 Year Vol	0.53 (6.89)*	-0.03 (-0.44)	0.01

Notes:

T-value in brackets.

* significant at 1% level.