Winners, Losers, and Regulators in a Nascent Derivatives Market: Evidence from Chinese Brokerage Data*

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Abstract

In contrast to a wealth of knowledge on trading in equity markets, comparatively little is known about who gains and who underperforms in derivatives trading. We consider these issues in the context of an episode in China where equity investors obtained access to warrants due to regulatory reform, in an environment without other established options markets. The data, which allow us to analyze how well agents comprehend unfamiliar and complex contracts in their initial evolutionary stage, reveal that individual investors trade warrants with high skewness and pay for high skewness, while institutions do not. A considerable number of investors treat expiring deep OTM warrants as stocks, and pay positive prices for warrants that assure a reduction in investment capital owing to price limits in the underlying asset market. Price limit rules for the warrant market are set such that they often preclude convergence to fundamentals, which materially affects investors' profits. Investors earning the most profits are active traders and hold the least amount of warrants interday. Small investors tend to hold warrants for a relatively long period, which adversely impacts their performance. Overall, our results highlight the importance of ensuring financial sophistication amongst investors and regulators in derivatives markets.

Keywords: Warrants; Financial sophistication; Trading performance; Individuals/institutions; Lotteries

JEL Classification: D03, D81, G02, G12, G23

1 Introduction

Options markets are popular around the world, but little is known about the relation between investment profits and trader type in these securities. A related question is whether agents who trade these claims fully understand the associated complexities. In this paper, we shed light on these issues by using proprietary account-level brokerage data to study trading patterns in Chinese options; specifically, warrants. Our institutional setting is unique because the warrants were made available to equity investors as compensation arising from split share reform,[1] in the absence of other established options markets. Thus, stock investors obtained access to a security that was likely unfamiliar to many of them. How such investors traded these non-linear securities in the secondary market is therefore of particular interest, as it potentially can shed light on whether investors are able to grasp the nuances of derivatives in a timely fashion during the initial evolutionary stage of the market.

We investigate the precise sources of profits and the categories of investors that over- and under-perform in the warrants market. Our dataset facilitates this study by allowing us access to trading histories of common stocks and warrants for 1.8 million investors during a period of 678 trading days. Day end holding summaries are also available. Further, the data allow for distinguishing institutions from individuals. To the best of our knowledge, an analysis of profits by trader type in derivatives markets has not been conducted in previous literature.[2]

[1] Specifically, they were given out to offset investor losses arising from an increase in supply of shares as a result of converting non-tradeable shares to tradeable ones.

[2] Many other studies have analyzed the Chinese warrant market, but not by trader type. Xiong and Yu (2011) and Gong, Pan, and Shi (2017) find that short-sales constraints, heterogeneous beliefs, and a continuing influx of new investors play important roles in driving bubbles (episodes of seeming overvaluation) in this market. The evidence in Xiong and Yu (2011) supports the feedback loop theory of bubbles (wherein initial investors who push up prices attract more investors) proposed by Shiller (2000). This latter point is further studied by Pearson, Yang, and Zhang (2017) using brokerage account data. Liu, Zhang, and Zhao (2014) document that there are spillover effects from speculative activities in Chinese warrants to the underlying stocks. Liao et al. (2010) argue that mechanisms which facilitate short-sales can mitigate bubbles in the Chinese warrants market. There are also some papers which focus on the mechanisms of Chinese warrant bubbles in Chinese journals; see Bian and Tie (2010), Zhang, Liao, and Shen (2013), Wang, Zhu, and Zhang (2012), and Pan, Shi, and Song (2008) among others. Zhang, Wang, and Liao (2011)

The warrants market was extremely active at its peak. For example, during 2005–2011,[3] trading activity in this market surpassed that of more established warrant markets in Hong Kong and Germany; thus, turnover in Chinese warrants was $250.5 billion in 2006, while that in Hong Kong and Germany was $230.4 billion and $124.3 billion, respectively (Mitchell 2007; Chung 2007). Turnover peaked in year 2007 at 7.78 trillion yuan, or about 28.8% of Chinese GDP in the same year.[4] Thus, the economic significance of warrant trading was material, emphasizing the relevance of our study.

We first exploit the cross-sectional properties of investors' portfolios such as profitability, average moneyness, leverage, intraday volatility, ex ante skewness,[5] and other variables to show that, overall, individual investors actively trade warrants with high skewness and overpay for high skewness, while the patterns for institutions are weaker. Overall, institutions earn positive profits, while individuals suffer a material decrease in wealth by trading warrants. The adverse effects of ex ante skewness on individuals' profits are salient even after controlling for many other warrant characteristics such as delta, vega, gamma, price and relative value (fundamental value over trading price). In a phenomenon that contributes to their underperformance, small investors tend to hold out-of-the-money warrants for relatively long periods. In fact, we show in the paper that many of these un-liquidated long positions guarantee a profit of -100% due to price limits in the underlying asset market. Further, these derivatives positions are often held at prices that signify regulatory naïveté, in that the lower price limits in the *warrant* market are, on occasion, high enough to not only exceed fundamental values but also the maximum possible

investigate whether individual investors exhibit a disposition effect in warrant markets.

[3]The first warrant (BaoGang JTB1, 580000) was listed on August 22, 2005, while the last warrant (ChangHong CWB1, 580027) expired on August 11, 2011.

[4]On May 30, 2007, the Chinese government increased the stamp tax for stock trading, which caused a stock market crash and (slightly) reduced turnover in the Chinese stock market. However, this policy triggered a material turnover increase in the Chinese warrant market; see Powers and Xiao (2014) and Cai et al. (2017).

[5]We define ex ante skewness as the third central moments of warrants' payoff at maturity; see Boyer and Vorkink (2014) and Li, Subrahmanyam, and Yang (2018).

payoffs on the warrants.

We investigate the link between trading patterns and performance. Empirical analyses based on classification by investors' profitability show that institutions do not invariably perform better than individuals: there are many naïve institutions. Highly profitable investors trade a lot while holding less: the top 0.1% of investors (by profitability) trade about 10 times per day, their trading volume accounts for 44.2% of the total, and their aggregated holding position only amounts to 4.1% of their aggregated trading volume. We find that over 90% of investors' underperformance is due to out-of-the-money (hereafter, OTM) expired warrants during the last few trading days of these warrants. We further study the time series properties of investors' trading behavior in these OTM expired warrants. We find that both institutions and the top 0.1% of investors trade extensively during the last few trading days, and that both groups hold fewer warrants as maturity approaches: actually, the top 0.1% group clear most of their position on the last trading day. During the last four trading days, the middle (in terms of total profits) group *increase* their holding positions, which materially affects their adverse performance. We find that a considerable number of investors appear to adopt a so-called "doubling" strategy (i.e., scaling up positions to recoup past losses), which is very dangerous for OTM warrants that are very close to maturity.[6] This indicates limited understanding of the nascent options market, as they seem to trade warrants as a lottery-type investment in stock, where a complete forfeiture of investment is unlikely, as opposed to OTM options, where it is highly likely.

To further ascertain the sources of investors' trading performance, we split their profits into those related to day trade and those emanating from interday holdings. Transaction costs are included in the computations. The results based on investors' classification by profitability re-

[6] Poteshman and Serbin (2003) find that many investors exercise American calls irrationally. Barraclough and Whaley (2012) show that, during January 1996 to September 2008, failures to exercise in a timely manner cost put option holders dearly. Liao et al. (2014) also document irrational exercise behavior in options. Jensen and Pedersen (2016) find that, when market frictions are taken into account, a large portion of early exercises are in fact rational.

veal that 60% of the profits of the top 0.1% of investors are due to day trading which, together with the fact that they do trade very actively, indicates that a considerable proportion of top investors are sophisticated and skilled. In contrast, most of the investor underperformance (i.e., capital loss) occurs due to interday *holdings* in OTM expired warrants, and are related to the fast decay of warrants' time value during the same period. During the last five trading days of these OTM warrants, the bottom 10% of investors hold more than 60% of the warrants, and their trading volume accounts for more than 40% of the total. Thus, the evidence indicates that holding and, in fact, scaling up positions in OTM warrants near expiration are key sources of adverse performance in derivatives trading.

There are several papers on the topic of trading performance. Work on the wealth effects of trading including Barber and Odean (2000) and Barber et al. (2009) shows that individual investors materially underperform in trading common stock. Options are more complex than stocks, however, underscoring the importance of analogous studies for such contracts. Indeed, Lakonishok et al. (2007) show that textbook-style trading strategies are seldom used in options market, and that naïve investors mainly use options for speculation. Bauer, Cosemans, and Eichholtz (2009) show that most individual investors suffer significant losses in their options trading. Boyer and Vorkink (2014) show that investors appear to treat stock options as lotteries. Li, Subrahmanyam, and Yang (2018) show that securities issuers in Hong Kong earn (and investors lose) billions by trading a structured product named a Callable Bull/Bear Contract, which is essentially a knock-out option. In a similar vein, Bali and Murray (2013), Byun and Kim (2016) and Blau, Bowles, and Whitby (2016) also show that gambling preference can help explain cross sectional option returns.[7]

[7] Garleanu, Pedersen, and Poteshman (2009) argue that demand-pressure effects are helpful in explaining some option pricing puzzles. Coval and Shumway (2005) show that behavioral biases of investors influence their trading behavior in futures markets.

We have four points of departure with the existing literature that justify our Chinese context. The first is that, as we pointed out earlier, the Chinese warrants market came into existence in the absence of an established market in options within that country. The question of whether investors who suddenly obtained access to an unfamiliar derivatives contract properly understood the security is an intriguing one.[8] Second, our brokerage account data, unlike other data on derivatives trading, allow us to analyze the cross-sectional properties of trading behavior and profits among specific types of derivatives investors (institutions and individuals separated by account size).[9] Third, because of price limits in the underlying cash market we are able to pinpoint previously unexplored rationales for the losses suffered by investors and complement the existing empirical findings. Specifically, we show that investors overpay for deep OTM warrants that have *zero* chance to expire in-the-money owing to price limits in the underlying stock. Indeed, many agents hold these warrants all the way up to the last trading day for a guaranteed reduction in capital starting several days prior to expiration, even as the instrument continues to trade at non-trivial prices. Fourth, via an analysis of the price limit rule in the *warrant* market, we are able to emphasize the need to ensure regulatory authorities are properly informed about the complexities of derivatives. Specifically, we find that in many circumstances, the lower price limit is higher than the corresponding day-end fundamental value of the warrant. This indicates that regulatory policy contributes to investors' adverse performance by precluding convergence of prices to fundamental values.

To summarize, our central results are as follows: (i) individual investors trade warrants with

[8]There was in fact warrant trading in China from June 1992 to June 1996. However, this was a market introduced at a time when there were only 1.1 million stock accounts in China, compared to 71 million at the end of 2007 (http://www.sse.com.cn/aboutus/publication/factbook/). It is therefore unlikely that warrant investors during our sample were familiar with the earlier market which was about a decade older. In related work, Black and Scholes (1972) and Moore and Juh (2006) consider option pricing in the pre-Black and Scholes (1973) era, but do not consider trading patterns and profits by trader type.

[9]Gong, Pan, and Shi (2017) and Pearson, Yang, and Zhang (2017) also use brokerage account data, but they mainly focus on the time series characteristics of warrants and investors in explaining bubbles in the warrant market.

extremely high ex ante skewness and their profits are negatively related to contract skewness; (ii) institutions' profits and trading do not exhibit such systemic behavior although a fairly large portion of institutions also trade warrants with high skewness; (iii) top-performing investors are those who trade actively and hold the least amount of warrants interday; (iv) small investors tend to hold warrants for a relatively long period, which contributes considerably to their sub-par performance; (v) a substantial portion of investors treat warrants as stocks, and they use stylized strategies adopted from the stock market in trading warrants, which causes them to pay positive prices for securities that assure a profit of -100%; (vi) in many scenarios, the lower price limit of warrant trading is higher than the contract's theoretical value (indeed, in a few cases, the lower limit is even higher than the corresponding *maximum possible* payoff). Thus, overall, our analysis supports the argument that many investors and policymakers did not fully understand derivatives markets, which adversely impacted trading capital. This underscores the importance of ensuring adequate financial sophistication amongst investors and designers of trading mechanisms for complex securities.

The next section of the paper briefly introduces the Chinese warrant market and presents some related summary statistics. We present empirical studies on driving forces of investors' profits/losses in Section 3. Section 4 examines trading behavior by investor classification. In Section 5, we illustrate that a specific trading mechanism (price limits) is related to investors' performance and provide evidence that investors seem to treat warrants as stocks. Section 6 concludes the paper.

2 The Chinese Warrants Market and Our Dataset

In this section, we first review some institutional details about the Chinese warrant market. We then describe our dataset and provide some summary statistics of interest.

2.1 The Market for Warrants

The Chinese warrants market was a product of the split-share structure reform in China started in 2005. Warrants were introduced as compensation to public investors to for their potential losses due to the reform.[10] The trading mechanism for warrants was very much like that of stocks. Specifically, warrants were exchange-listed and investors could trade warrants using their stock accounts only if they signed a "Warrant Risk Disclosure Letter".[11] Some important characteristics of Chinese warrants market included: (1) a daily price-limit mechanism, which means that only trades with prices that belong to some interval can be executed, (2) unlike the Chinese stock market (in which the purchased stock cannot be sold in the same trading day), the Chinese warrants market allowed intraday trading. We provide some relevant institutional details about the market in Appendix A.

Only some specific issuers were able to short sell warrants. For a subset of warrants listed in Shanghai Stock Exchange (hereafter, SSE), additional qualified security brokerage firms (non-issuers) could also short sell warrants (please refer to Table 1 for details). Outside investors could

[10] See Xiong and Yu (2011) and Gong, Pan, and Shi (2017) for details. Most companies completed split-share reforms in 2006. The last warrant stemming from the reform was EJiao EJC1 (031007.SZ), which was listed on Shenzhen Stock Exchange on July 18, 2008. The other source of warrants was the so-called warrant-bond (bond with separable warrant), a financing tool used by some companies. The last warrant-bond, the ChangHong CWB1 (580027.SH), was listed on July 21, 2009. Please refer to the CSRC's official website (in Chinese) http://www.csrc.gov.cn/ for details.

[11] Due to slack supervision, many brokerage firms did not comply with this rule, i.e., they allowed their clients to trade warrants before they signed the disclosure letter. Actually, the Shanghai Stock Exchange released many notices (on August 5 and 24, 2005, and July 24, 2007) to emphasize the importance of signing the letter. A large brokerage firm, PingAn Securities, announced as late as February 5, 2007 that existing warrant investors could not buy warrants after February 17, 2007 if they had not signed the letter by then. In sum, the requirement to sign the disclosure letter was unevenly enforced.

not short sell warrants. Also note that, in China, there were no exchange traded options until February 9, 2015, and that short selling of stocks was prohibited prior to March 30, 2010.

2.2 Data Description and Summary Statistics

Our dataset, kindly provided by a large (top ten in China) brokerage firm, spans the period January 4, 2007 to October 16, 2009, which includes 678 trading days. The dataset consists of 21.2 million warrant trading records (including warrant exercises) by 223,745 warrant investors.[12] Only 246 or 0.12% of them are institutional investors.[13] The data account for more than 3% of both the aggregate trading volume and the aggregated turnover value of the entire warrant market during the same time period. Each trading record contains the following information: account ID, stock code, trading price, trading volume, trading date, trading time (accurate to one second), trading direction (buy or sell), business balance (i.e., the absolute value of trading value in CNY), clear balance (i.e., the signed change in the cash balance due to the trade), and the commission fee incurred by the trade.

There were 48 warrants (written on 41 different underlying stocks) traded during this sample period. Table 1 reports meta information for these warrants. 35 of them (code starts with 58) were listed on the SSE, and the remaining 13 (code starts with 03) warrants were listed on the Shenzhen Stock Exchange. 14 out of these 48 warrants were put warrants.[14] Initially, these 48 warrants

[12]The full dataset includes trading records of stocks, warrants, funds, government bonds, corporate bonds, and convertible bonds for 1.8 million investors. We delete trading records for 10,579 investors who were dispatched warrants for free, since: (1) the dispatch would perturb the calculation of their profits; and (2) 87.9% of these investor simply sold their warrants and then never reentered the market. As such, ignoring these investors should have virtually no effect on our main results.

[13]This proportion and later statistics about turnover value contributed by institutions are consistent with weekly reports published by SSE INFONET LTD, a wholly-owned subsidiary of Shanghai Stock Exchange. See also Section III.C in Xiong and Yu (2011). Amongst these 246 institutions, there are no mutual funds, or QFIIs (Qualified Foreign Institutional Investors).

[14]Only one warrant (NanHang JTP1, 580989) is cash-settled, while all other warrants are physically settled. Just a single warrant (ChangDian CWB1, 580007) has a "put provision": during the exercise period, warrant holders have the additional right of selling their warrants back to issuer at a price 1.8 CNY per share. As a matter of fact, the closing price of Warrant ChangDian CWB1 on its last trading day was 8.761, so the "put provision" did not in fact take effect.

were not sold to investors, but were dispatched to qualified investors either as compensation for split-share structure reform (the column Source equals 1 in Table 1), or in the form of separable warrant-bonds (Source equals 0). The column "Share" reports the number of circulating shares determined in the initial issuance process. For some warrants (those with MShare>Share in Table 1), except for their initial issuance, SSE allows a group of qualified brokerage firms to originate (create, or short sell) additional shares. The column "MShare" reports the maximum end-of-day circulating shares during the lifespan of each warrant. The column IRP reports the initial reference prices for all warrants, which are used in the opening call auction to determine the price limits on the first trading day for each warrant.

The column Money in Table 1 reports, for each warrant, its moneyness at the end of its last trading day. We define moneyness as $\log(S_T/K)$ ($-\log(S_T/K)$) for call (put) warrants. Thus, a positive (negative) moneyness means that the warrant expired in-the-money (out-of-the-money). There are 23 warrants that matured out-of-the-money, and the moneyness ranges from -1.969 to 2.156. Recalling the logarithm-style definition of moneyness, a moneyness of -1.969 (2.156) indicates a status of *extremely deep* out-of-the-money (in-the-money). In the last four columns of Table 1, we also report the trading period and exercise period for each warrant. All put warrants are European style with length of exercise period of no more than one week. Call warrants are either European style or Bermudan style, with lengths of the exercise period ranging from one week to about one year.

Table 2 presents sample averages (across warrants in each group) for some variables of interest. The second to seventh columns in Table 2 report sample means for the total number of investors, the total number of institutional investors, moneyness as of the last trading day, total trading volume, total turnover value, and average turnover value per investor across warrants. We find from Table 2 that, on average, the number of investors trading OTM warrants is signif-

icantly higher than that trading in-the-money (hereafter, ITM) warrants, and the average total trading volume for OTM matured warrants (24.1 billion) is also significantly higher than that for ITM matured warrants (6.0 billion). The averaged total turnover value for OTM matured warrants is higher than that for ITM ones, but statistically insignificant. All these facts indicate that investors have a proclivity towards trading warrants that expire OTM. However, the columns GroProf (gross profit) and NetProf (net profit) in the same table reveal that investors suffer considerable underperformance in trading warrants expiring OTM. Indeed, the aggregated gross profit from trading OTM (ITM) warrants is -897.3 million CNY (227.1 million CNY); the aggregated net profit from trading OTM (ITM) warrants is -1376.3 million CNY (-86.7 million CNY).[15] The next section will explore warrant investors' profit patterns as well as factors that drive these patterns.

Figure 1, which presents the proportion of aggregated trading volume in in each moneyness[16] bin, shows that trading in warrants is diversified in terms of moneyness. In particular, there is extensive trading even when moneyness is below -1.[17] Note that the deep OTM warrants have extremely high ex ante skewness and that, *ceteris paribus*, options with shorter time to maturity have higher ex ante skewness; see Boyer and Vorkink (2014). Figure 2 shows that ex ante skewness of warrant returns can be extremely high when warrants are *extremely deep* OTM, and that the pattern is more salient for warrants with short time to maturity. So these distributional properties of trading volume seem consistent with those observed in Callable Bull/Bear Contracts (CBBCs) market of Hong Kong, in which investors are mainly attracted by CBBCs' high

[15] As for individual warrants, NanHang JTP1 (580989) generates the most adverse performance, attracts the most investors and the highest trading volume among all 48 warrants studied here. Warrant ZhaoHang CMP1 (580997) is the most deep OTM expiring one. Warrant 580026 (JiangTong CWB1) generates the most net profits of 82 million CNY, while warrant 580006 (YaGe QCB1) is the most profitable one in terms of averaged net profits per investor.

[16] In this paper, owing to the existence of extremely deep in- or out-of-the-money warrants, we define moneyness as $\log(S_t/K)$ ($-\log(S_t/K)$) for call (put) warrants. Thus, roughly speaking, a negative moneyness indicates out-of-the-money status for both call and put warrants.

[17] The reader may wonder whether investor interest in OTM warrants is diversified or concentrated in one or two warrants. Figure OA.1 in the online appendix shows that there is in fact interest in OTM warrants on multiple stocks.

skewness, and thus tend to trade more when CBBCs' ex ante skewness is higher; see Li, Subrahmanyam, and Yang (2018). However, it will be clear later that, although high ex ante skewness in CBBCs implies a gambling opportunity, the extremely high ex ante skewness in deep OTM warrants is in many cases associated with an assured reduction in capital for investors who hold them till maturity, even as these contracts command positive prices.

3 Warrant Characteristics and Investors' Profits

In Table 3 we report summary statistics on gross profit (excluding transaction fees), net profit (including transaction fees), trading volume, turnover value, number of trades, and averaged value per trade, for different groups of investors. Panels A and B in this table show that the gross profit for institutional investors is 17.9 million CNY, and the net profit decreases to 9.6 million CNY. For individuals, the gross profit is negative at 0.69 billion CNY and, when transaction fees are taken into account, becomes 1.47 billion CNY (about $220 million). These numbers mean that transaction fees reduce institutional (individual) investors' gross profit by 46.4% (53.3%). These numbers reflect the fact that, although the transaction cost is much lower than that for the contemporary Chinese stock market, the turnover ratio in Chinese warrant market is extremely high; see Chung (2007), Xiong and Yu (2011), and Cai et al. (2017).

Panels C–E of Table 3 show that the gross trading volume is 0.71 trillion shares and the corresponding turnover value is 1.50 trillion CNY (about $220 billion); on average, individuals (institutions) trade 95 (110) times during our sample period; slightly more than 1% of investors trade more than 1100 times. The average turnover value for individuals is 6.7 million CNY, while that for institutions is 41.5 million CNY, about six times of that for individuals. Panel F of Table 3 shows that the average value per trade for institutions, at about 0.3 million yuan, is more than

ten times that for individuals (less than 0.03 million yuan). Table 3 also reveals that, for all quantities reported here, the distributions for individuals are severely right skewed, while those for institutions are relatively symmetric. This implies that institutions are more homogeneous than individuals: there are a few "super" individual investors who trade a lot and/or make a lot of money. This last phenomenon is consistent with weekly reports published by Shanghai Stock Exchange which indicate that the Chinese warrants market is dominated by about three or four thousand such "super" individuals.

It is now known that warrant investors underperform, but what factors drive investors' profits/losses? Figure 1 shows that, in the Chinese warrants market, deep OTM options appeal to investors. It will be clear that investors suffer a material reduction in capital by trading these warrants.[18] This last fact is intriguing (or even surprising). Why is the trading volume in deep OTM warrants so high? Since warrants that go very *deep OTM* and have *very short* time to maturity are very unlikely to end up ITM, neither crash insurance (Jackwerth 2000) nor insider trading (Chakravarty, Gulen, and Mayhew 2004) can explain the popularity of these warrants.

One possible explanation of this specific phenomenon may be that investors are attracted to lottery-type securities, since deep OTM warrants can provide lottery-like opportunities at low prices. The theoretical study of Barberis and Huang (2008) predicts that investors with cumulative prospect theory utility are willing to pay premiums for lottery-like opportunities.[19] Empirical evidence reported in Gao and Lin (2015), Barberis, Mukherjee, and Wang (2016), Cookson (2018), Li, Subrahmanyam, and Yang (2018), and Cole, Iverson, and Tufano (2017) also shows that investors prefer lottery-type securities. This research motivates us to consider skewness preference (or lottery preference) as a driver of trading behavior in this market.

[18] In fact, we know from Table 2 that 94.1% of the overall adverse performance is due to OTM expiring warrants.

[19] Kumar (2009), Boyer, Mitton, and Vorkink (2010), Bali, Cakici, and Whitelaw (2011), and Green and Hwang (2012) study investors' preferences for lottery-type stocks.

We conduct cross-sectional regressions of investors' aggregate profits and aggregate trading volume on value-weighted variables including skewness, leverage, volatility, moneyness, delta, vega, gamma, relative value, and the closing price. Here skewness is defined as the third central moment (see Boyer and Vorkink 2014 and Li, Subrahmanyam, and Yang 2018), and computed under the log-normal assumption, i.e., under the framework of Black and Scholes (1973) and Merton (1973);[20] we use the price elasticity (or implied leverage) with respect to the underlying asset price, defined as $\frac{dP(S)}{dS} \times \frac{S}{P(S)}$ (S and $P(S)$ denote the underlying price and the warrant price respectively), as a proxy for leverage; we adopt an intraday volatility measure defined as $\frac{Day\ High - Day\ Low}{Previous\ Day's\ Closing}$; moneyness is defined as $\log(S_T/K)$ ($-\log(S_T/K)$) for call (put) warrants; relative value is defined as the Black-Scholes-Merton (BSM) value divided by the market price; delta, vega, and gamma are also computed under the Black-Scholes-Merton framework.

Since many of these variables are highly skewed (see Table 3), we instead use the corresponding sorted variable (we assign the number i to an observation if it belongs to the i-th percentile). For each variable (including the independent ones), we average the corresponding sorted variable across each group determined by the percentile of the independent variable. In this way, each variable has 100 values (i.e., percentile ranks).

Table 4 reports the regression results across all investors. We find that, in bivariate regressions, both gross profits and net profits are negatively related to ex ante skewness and volatility, and positively related to leverage, moneyness, delta, and price. Gross profits are positively related to vega and gamma; after taking transaction costs into account, net profits are actually negatively related to vega and gamma. In multivariate regressions that include all explanatory variables (the last column), skewness remains negatively related to both gross and net profits, indicating

[20] We use the HIBOR rate as the risk-free proxy, and use 60-day trailing historical volatilities of the underlying asset as volatility estimates. [We also use 126-day and 252-day versions as robustness checks; the results are virtually unchanged.]

the importance of ex ante skewness in explaining losses. The coefficients of skewness in the multivariate regressions indicate that a one rank increase in skewness implies a decrease in investors' gross (net) profits of CNY 104.1 (CNY 126.9) per million in trading value.[21] After controlling for other variables, volatility becomes insignificant and in fact flips sign. The positive coefficients for relative value (recall it is defined as BSM value over market price) mean that trading overpriced warrants could be hazardous to investors' wealth. We also run regressions of trading volume on all of the above independent variables. Panel C of Table 4 reports the results. We find that in bivariate regressions, trading volume is positively related to all explanatory variables except price. When we include all variables, the coefficient of skewness remains positive and significant. The coefficient on skewness of 1.21 implies that a one-rank increase in skewness, on average, is associated with an increase in trading volume of 3.1%. Note that, in all three panels of Table 4, skewness by itself has very strong explanatory power with adjusted R^2 higher than 60%.

The results in Table 4 are consistent with the notion in behavioral finance that investors like lottery-type opportunities and on average underperform in trading high skewness securities. We now consider whether sophisticated investors like institutions also have this kind of behavioral bias. To answer this question, we conduct analogs of Table 4 for institutional investors and individual investors separately. The results are reported in Table 5. In each panel of the table, the first (second) column presents results for institutions (individuals). In regressions for gross profits of institutions, only leverage, which is negatively related to gross profits, is statistically significant at the 5% level. Regression results for net profits of institutions reported in Panel B are similar. These results indicate that institutional investors pay for high leverage in trading warrants. The coefficient on leverage implies that if leverage increases by one rank institutional

[21] These changes are economically significant since we know from Table 3 that overall, the gross (net) loss per million trading value is CNY 446.7 (CNY 973.3).

investors' gross (net) profits decrease by CNY 245.4 (CNY 245.8) per million in trading value. Based on the low adjusted R^2-s for these regressions, institutional investors' profits do not exhibit strong patterns related to these explanatory variables. Panels C and D of Table 5 show that institutions also tend to trade more and hold more when skewness is high (a one-rank increase in skewness is associated with a 2.6% increase in institutional investors' trading volume); however, as shown in Panels A and B of the same table, they do not pay for high skewness.

In sharp contrast for individuals relative to institutions, however, the results reported in Table 5 show that individuals not only tend to trade more but also suffer adverse performance when skewness is high; i.e., they pay for high skewness. We find that a one-rank increase in skewness implies a decrease in individual investors' gross (net) profits of 202.1 CNY (223.9 CNY) per million traded value, and an increase in trading volume of 3.4%. Overall, the patterns exhibited in individuals' trading, in terms of statistical significance and explanatory power of independent variables, are much more transparent and strong than that for institutions. The results reported in Tables 4 and 5 are consistent with the fact that the Chinese warrants market is dominated by individual investors.

A material event in the Chinese warrant market is that, on May 30, 2007, the government increased the stamp tax on stock trading from 0.1% to 0.3%. A recent study by Cai et al. (2017) claims that since the Chinese warrant market was not subject to stamp tax, the event migrated trading from the stock market to the warrant market. To control for the effect of this event on our results, we also include a dummy variable in regressions reported in Table 5. For each investor, we first define an indicator variable which equals 1 if a trade occurs on or after May 30, 2007, and is zero otherwise. Then for each investor, the "Dummy" variable is computed as the value-weighted mean of the indicator variable across all trades by the investor. We find that the effect of this event is stronger on individuals than that on institutions. Specifically, the post-event period

is accompanied by greater trading and more underperformance for individual investors. This event, however, has no material effect on institutional investors' net profits.

In totality, the evidence accords with the view that investors' trading is high in lottery-type warrants and they also pay for the high ex ante skewness inherent in these securities. When we consider institutions and individuals separately, these patterns are mainly due to the preference of individual investors. In the next section, we will further take advantage of the brokerage account data to classify investors by trader type and profitability, and examine further the sources of profits.

4 Investors' Trading Behavior and Their Profit/Loss Patterns

4.1 Do Institutions Trade Warrants Smartly?

We have shown that, in aggregate, individuals pay for high skewness, while institutions do not. We wonder: (i) do these stylized facts mean that institutions perform systematically better than individuals? and (ii) does this evidence indicate that institutions eschew high skewness warrants?

To answer question (i) above, we first sort all investors by their total net profits, and divide them into nine groups (top 0.1%, 0.1% ∼1%, 1%∼10%, , 10%∼30%, 30%∼70%, 70%∼90%, 90%∼99%, 99%∼99.9%, and bottom 0.1%). We then compute the proportion of institutional investors in each group. The results are shown in Figure 3. We find that the proportion of institutions across the groups is *U*-shaped, which means that there are more institutional investors in the extreme groups than in the middle. The high proportion in the bottom-performing group indicates that we cannot claim that institutions perform systematically better than individuals. Specifically, our evidence shows that there are at least as many naïve institutional investors as

smart ones.

To further investigate warrant investors' trading behavior and address potential nonlinear relationships between variables of interest, we report various trading characteristics by end-of-day ex ante skewness in Table 6. Panel A in this table reports results for all investors, while Panels B and C present results for individuals and institutions, respectively. Column *N* reports the number of days (across all warrants) that lie in the corresponding skewness decile. The columns Volume, Turnover, Holding and TRatio report the averaged daily summaries for trading volume, turnover value, day-end holding position, and turnover ratio, respectively, for each skewness decile. We find from Panel A that investors tend to trade more and hold more when skewness is higher. The differences between extreme deciles are both economically and statistically significant. The results for individual investors reported in Panel B are quite similar to those reported in Panel A.

Panel C reveals that, although the differences between the extreme deciles are less sharp than those for individuals, institutional investors also trade a lot when skewness is higher: trading volume and turnover ratio in the highest decile are significantly higher than those in the lowest decile, though the difference in turnover value between the extreme deciles is insignificant.[22] Moreover, although the average holding position for institutions in the highest decile is lower than that in the middle deciles, it is significantly higher than that in the lowest decile. These results indicate that institutions do tend to trade actively when skewness is very high, which provides a negative answer to question (ii) posed at the beginning of this section. Specifically, we cannot find sharp evidence from trading behavior that can distinguish individuals and institutions, which may be due to the finding from Figure 3 that there exists a significant proportion

[22] Actually, average trading volume, turnover value, and turnover ratio in the highest decile are the highest amongst all ten deciles. Graphically, the average turnover value for institutions is almost uniformly distributed amongst deciles.

of naïve institutional investors. In fact, Panels A and B of Figure 4 reveal that institutions do trade actively when ex ante skewness is very high.

4.2 Profits by Investor Classification

To further study investors' behavior and their profit patterns, we separate profits into two parts: one due to day trading, and the other from interday holdings. In consideration of the fact that institutions also trade a lot when skewness are very high, and that there exist quite a few naïve institutional investors, we also group investors by their profitability and further study the trading characteristics for different groups of investors.

4.2.1 Splitting of Profits/Losses

Recall that Chinese warrant market allows for "$T+0$" trading, which means that, once an investor buys a warrant, he/she can sell it immediately on the same day. Also, the daily turnover ratio can be as high as hundreds of percent! Thus, to track investors' profits/losses more efficiently, we compute intraday trading profits ("Day Trade Profits") and interday holding profits ("Holding Profits") as follows. On each trading day, the "Day Trade Profits" for one specific warrant consist of the sum of signed (positive means sell, negative represents buy) cash flow due to the trading of this warrant, plus the daily net position change times the closing price of the warrant. The "Holding Profits" are computed as the daily price change times the held position at the end of the previous trading day. Mathematically, denote the sum of signed cash flow on day i as c_i, the net position change on day i as n_i, the holding position at the end of day i as h_i, and the closing price on day i as p_i. Then[23] the "Day Trade Profits" and the "Holding Profits" on day i are $c_i + n_i p_i$ and $h_{i-1}(p_i - p_{i-1})$, respectively. To add clarity, the splitting process is demonstrated in

[23] Assume $h_0 = 0$, $c_{k+1} = n_{k+1} = 0$, and $n_i = h_i - h_{i-1}$. Let p_{k+1} represent the exercise profits (if any) at the maturity day T.

Table 7.

Given the notations in Table 7, we have that the overall "Day Trade Profit" is

$$\sum_{i=1}^{k+1}\Big(c_i + n_i p_i\Big),$$

and that the overall "Holding Profit" is

$$\sum_{i=1}^{k+1} h_{i-1}(p_i - p_{i-1}).$$

More importantly, the sum of the "Day Trade Profit" and the "Holding Profit" is

$$\sum_{i=1}^{k+1}\Big(c_i + n_i p_i + h_{i-1}(p_i - p_{i-1})\Big) = \sum_{i=1}^{k+1}\Big(c_i + h_i p_i - h_{i-1}p_{i-1}\Big) = h_k p_{k+1} + \sum_{i=1}^{k+1} c_i,$$

i.e., the sum of all signed cash flows plus the exercise profit, which is exactly the total profit accrued from trading one specific warrant. We thus have successfully split the profits into two parts: "Day Trade Profit" and "Holding Profit". Note that, on each trading day, we can implement the above splitting process for every investor's trading in every warrant, so that we can compute the "Daily Profit" as the sum of the "Day Trade Profit" and the "Holding Profit" on the same day. It will soon be apparent that this way of splitting profits can provide more insights about investors profit/loss patterns.

As a first application, we can obtain that, overall, the "Day Trade Loss" (including transaction costs of CNY 0.793 billion) is CNY 1.315 billion, the "Holding Loss" (excluding exercise profits) is CNY 0.628 billion, and the final exercise profit is CNY 0.481 billion. For OTM expired warrants, the "Day Trade Loss" (including transaction costs) is CNY 0.469 billion, and the "Holding Loss" is CNY 0.907 billion, which accounts for 65.9% of total losses.

The last four columns of Table 6 show, for three groups of investors (full sample, individuals, and institutions), the averaged daily profits, day trade profits, holding profits, and transaction fees in each skewness decile. We find from Panel A that, for all investors, the average transaction fee for the highest skewness decile is significantly higher than that for the lowest decile, which is consistent with the fact that trading volume and turnover value for the highest skewness decile are significantly higher than that for the lowest decile. The daily profit, day trade profit, and holding profit for the highest skewness decile are negative and significantly lower than those for the lowest skewness decile, which is consistent with the results reported in Table 4 that, in aggregate, investors pay for high skewness.

The last four columns of Panel B in Table 6 present results for individual investors. Again, the results are quite similar to those reported in Panel A for all investors. We point out that, in terms of *t*-statistics, the differences between the extreme deciles for individual investors are slightly more significant than those for all investors, indicating that the patterns with respect to ex ante skewness reported here for individual investors are slightly more sharp than those for all investors.

The results for institutional investors are quite different. The difference in holding profits between extreme deciles is insignificant, while the difference in day trade profits between extreme deciles is both economically and statistically significant. Taking the two parts together, the difference in daily profits between extreme deciles is economically large but statistically insignificant. Moreover, consistent with the pattern in turnover value, the difference in transaction fees between extreme deciles is also insignificant. Another interesting finding here is that, on average, institutions' daily profits and day trade profits accrued in the highest skewness decile are positive and higher than those in the lowest decile.[24] This fact is consistent with the evidence

[24]In fact, for institutions, their average trading volume, turnover value, turnover ratio, day trade profits, and daily

from Table 5 that institutions do trade warrants with high skewness actively, but do not pay for this skewness via lower profits.

4.2.2 Study Based on Investor Classification

Recall the fact that institutions do not perform systematically better than individuals. In order to better understand investors' behavior on the Chinese warrants market, it is desirable to group investors by their profitability. The results are reported in Table 8. We find that, interestingly, the average value per trade is *U*-shaped: on average, the top 0.1% investors trade over CNY 0.44 million per trade, the bottom 0.1% investors also trade about CNY 0.27 million per trade, while investors in the 30th to the 70th percentiles trade less than 10 thousand yuan per trade. These findings indicate that there are "super" investors (i.e., investors with large portfolio values) in both tails. The value-weighted ex ante skewness is also *U*-shaped, which indicates that both the top and bottom 0.1% of investors heavily trade warrants with high ex ante skewness. Although the difference between the value weighted ex ante skewness for the top and bottom 0.1% of investors is statistically significant, the economic difference of 1.41 is very small since the range of ranked skewness is from 1 to 100. This evidence can be further verified by comparing Panels C and D in Figure 4. Thus, the evidence suggests that the top and bottom 0.1% of investors exhibit similar trading behavior. But there have to be some differences between these groups since their profitabilities exhibit the exact opposite patterns. We now proceed to look for such heterogeneities.

The fourth column of Table 8 shows that the average number of trades also depicts a *U*-shaped pattern, but is skewed toward the most profitable investors: this quantity for the top 0.1% of investors is more than 6 times that for the bottom 0.1% of investors. The column Turn. reports

profits are largest for the highest skewness decile. Detailed results are available upon request.

the proportion of total turnover value contributed by the various groups of investors, which is consistent with the pattern in number of trades: turnover value for the top 1% of investors accounts for more than 57% of the total. The turnover value for the top 0.1% accounts for more than 44% of the total, which is more than 10 times that of the bottom 0.1%.

Aside from trading behavior, we are also interested in investors' warrant-holding behavior. To this end, for investor i, we define a measure as follows

$$HRatio^i := \frac{\sum_{\{W,\,t\}} HoldingPosition^i_{W,\,t}}{\sum_{\{W,\,t\}} TradingVolume^i_{W,\,t}},$$

where $HoldingPosition^i_{W,\,t}$ and $TradingVolume^i_{W,\,t}$ represent investor i's day-end holding position and daily trading volume for warrant W on day t. So the holding ratio, $HRatio^i$, is the ratio of aggregated holding position over aggregated trading volume for investor i. The sixth column of Table 8 shows that the average holding ratio for the bottom 0.1% of investors is more than ten times higher than that for the top 0.1%. The holding ratio is also a salient characteristic that differentiates the group of top 0.1% investors from other groups: the ratio for each other group is at least five times higher than that for the top 0.1% group.

In summary, both the top and bottom 0.1% of investors trade a lot when ex ante skewness is high, but the top investors trade much more actively and hold smaller positions interday. As a result, the column labeled PpTurn (profit per turnover value) in Table 8 shows that the top investors' profits account for 0.09% of their total turnover value, while the bottom investors' losses account for 0.64% of their total turnover value. Table 8 also reveals that, in aggregate, the net profit (NetP) of the bottom 0.1% of investors (by profitability) accounts for more than one quarter of the total. Moreover, the columns HoPRatio and FareRatio show that, for the most profitable 0.1% of investors, the holding profit accounts for less than 40% of the total net

profit, and transaction costs account for more than 18% of their net profit. The low proportion of holding profit and the high transaction cost incurred by the top 0.1% investors indicate that a considerable proportion of top investors are sophisticated and skilled.

Readers may be wondering if big investors can perform systematically better than small investors. To this end, we sort investors by value per trade[25] (a proxy for investor size) and report characteristics of interest in Panel B of Table 8. We find that, on average, only super investors (top 0.1%) and big investors (top 1%) profit via their trades. The big investors are also those who trade more frequently and hold less. Interestingly, it is the smallest investors (bottom 0.1%) who trade warrants with extremely high ex ante skewness. Here, the pattern in ex ante skewness is much clearer than that in Panel A. The small investors (bottom 10% in terms of value per trade) also tend to hold warrants for several days on average. For tiny investors (bottom 0.1%), the ratio of net loss to total trading value is 78.81%!

In the last two columns of Table 8, we report the number of investors that had ever held put warrants and their underlying stocks simultaneously.[26] We find that there are 2,539 put warrant investors (3 institutions) that had ever held the corresponding underlying asset. The average holding period length is 31.4 (14.0) trading days for individuals (institutions). The distribution of these investors is quite symmetric among different groups by investors' profitability. So it is unlikely that rational hedging needs drive the profit/loss patterns.

Note that trading performance in warrants, as opposed to that in stocks, can be more readily traced to investor sophistication or lack thereof. Specifically, in equity markets, it may be difficult to ascertain if a winning (losing) trader is sophisticated (naïve) or he/she is just lucky (unlucky) over a short period. But in an options market, holding deep out-of-the-money options that are

[25] Since Chinese warrants allow for "$T+0$" trading, intraday trades can offset each other. This implies that aggregate trading volume does not contain reliable information about the capital strength of investors.

[26] During our sample period, short selling of common stocks is prohibited in China.

very close to maturity is clearly an unwise strategy. More specifically, we show in Section 5 that some warrant holders hold positions whose values are assured of falling to zero.[27]

To show that these trading and holding behaviors could play important roles in distinguishing the profitability of the top group versus that of the others, we next turn to the trading behavior of different groups of investors in deep out-of-the-money options.

4.3 Trading and Profits in OTM Expired Warrants

Recall from Table 2 that the bulk of investors' underperformance can be attributed to OTM matured warrants. It is worth further looking at trading behavior during the period right before the maturity date, since investors trade very actively during this period. We are particularly interested in time series variations for trading volume, day end holding positions, day trade profits, as well as holding profits for different groups of investors. Figure 5 shows the average closing price and average turnover ratio during the last 50 trading days for all OTM expired warrants. We find that significant changes in price and turnover ratio occur when the time to maturity is close to 10 days, and the pattern is very clear for the last five trading days. So we next focus on the behavior during the last 10 trading days. The results are shown in Tables 9 and 10.

Panel A of Table 9 shows that the averaged (across OTM expired warrants) proportion of trading volume by the top 0.1% of investors decreases gradually during the last four trading days, while that by the bottom 10% increases considerably during the same time. Changes in volume due to group $(0.1\% \sim 10\%)$, group $(10\% \sim 90\%]$, and the group comprised of institutions are relatively small. Interestingly, on the last trading day, the proportion of trading volume

[27] Another issue is whether investors who experienced capital reductions did so in just one or two warrants, or extremely correlated warrants. In this respect, note that we have 48 warrants written on 41 different underlying stocks, and that there are both calls and puts. Figure OA.2 in the Online Appendix shows the histogram of pairwise correlation coefficients of closing prices among all 48 warrants, and shows that there is sufficient heterogeneity in our sample. Further, Figure OA.3 in the online appendix demonstrates that the per capita net profit is relatively diversified across 48 warrants.

by institutions is still very high. Noting from Figure 2 that deep OTM warrants with a short time to maturity have extremely large ex ante skewness, this last observation is consistent with our early findings that there are naïve institutions who actively trade warrants with high skewness.

Panel B of Table 9 shows the holding patterns for different groups of investors. It is known that holding deep OTM warrants that are close to maturity is dangerous. As expected, the top investors "know the rules:" The top 0.1% almost completely clear their position, and the top 1% of investors also lower their position significantly as maturity approaches. The aggregated position of the bottom 10% investors does not exhibit any clear pattern. The most striking phenomenon occurs for the middle group $(10\% \sim 90\%]$: during the last four trading day, the position proportion increases by more than 75%! Recall from Figure 5 that, during the last four trading days, the average price of OTM warrants decreases from over 1 CNY to less than 0.2 CNY, a decrease of more than 80%! The holding behavior of "middle" investors is reminiscent of a "doubling" strategy in stock trading: after suffering significant losses, investors increase their position (to profit from a potential rebound of the stock price). However, it is also known (at least among sophisticated option traders) that the doubling strategy is inappropriate for deep OTM options which are very close to maturity, since the price decrease is the natural decrease due to the decay of time value in option prices, i.e., there is unlikely to be a rebound.

By analyzing account level trading data for the Baosteel call warrant (code: 580000.SH), Gong, Pan, and Shi (2017) show that the inflow of new investors is important in initiating and sustaining overvaluation in this warrant. We next address the issue of whether it is first-time (new) or existing investors that hold OTM warrants as maturity approaches. Figure 6 reports the proportions of aggregated position in OTM warrants by investor type. On each trading day, we split holding positions into three parts: the first consists of positions held by new investors (investors that first trade the specific warrant on that day), the second is the sum of net daily

position changes by existing investors who increase positions on that day, the third includes the remaining positions. We find from Figure 6 that a significant portion of holdings is due to existing investors who increase their day-end holding position, and that many investors hold OTM warrants interday as maturity approaches. While investors may choose to hold OTM warrants till maturity due to a reluctance to realize their losses (the disposition effect–viz. Odean 1998), note that in an options market, investors' losses are mandatorily realized at maturity with a rebound being extremely unlikely.

Panel A of Table 10 shows the averaged day trade profit from trading OTM expiring warrants. We find that individuals' holding profits are more severely affected by holding, as opposed to conducting day trades in OTM warrants when close to maturity. While top investors (top 0.1% and $(0.1\% \sim 10\%]$) can profit by conducting day trades on OTM warrants even when they are very close to maturity, the opposite is true for the two groups ($(10\% \sim 90\%]$ and bottom 10%). However, as expected, Panel B of shows that holding warrants close to maturity hurts even the top investors' (top 0.1% and $(0.1\% \sim 10\%]$) profits. Consistent with the increasing positions by group $(10\% \sim 90\%]$, holding warrants materially increases adverse performance for this group during the last four trading days. Combining Panels A and B, Panel C of Table 10 shows the daily profits with respect to the number of days to maturity. We find that no group of investors make substantial profits by trading deep OTM warrants that are very close to maturity.[28]

We have shown that a considerable number of investors traded OTM warrants very actively when these warrants were very close to maturity. Although the prices of these warrants were generally very low and their ex ante skewness was high, we will show in the next section that in many cases, given the specific mechanism of the Chinese warrants market, the return in many

[28] In Tables 8–10 and Figure 6, the sorting on investors' profitability is based on the full sample. When we classify investors by partial sample obtained through excluding the 20 (resp. 10) days before the last trading day of OTM expired warrants, the results are qualitatively similar. If fact, Figure OA.4 in the Online Appendix shows that investors' order of full sample profits is highly correlated with partial profits that exclude the last few days before expiration.

cases was actually an assured -100%.

5 Lottery or Guaranteed Reduction in Capital?

In this section, we first conduct a case study on a deep OTM matured warrant, the ZhongYuan CWB1, which can help us to better understand the sources of investors' profits. We then review the price limit rules in the underlying asset *and* in the Chinese warrant market, which shows that investors and regulators were not fully familiar with the derivatives contract; this contributed to investors' adverse performance.

5.1 Case Study: ZhongYuan CWB1 (580018)

After the split-share structure reform launched in China, the so-called warrant-bond (i.e., bond with detachable warrants) became one of the important instruments for refinancing. On January 28, 2008, the COSCO SHIPPING Company Limited[29] (hereafter, COSCOL) issued 10.5 million warrant-bonds with a face value of 100 yuan. The issue price was also CNY 100 yuan. For every ten bonds held, the subscriber obtained 49 warrants, the ZhongYuan[30] CWB1 (580018.SH). As such the total number of warrants circulated was 51.45 million, which was fixed during the lifespan of the warrant.

The ZhongYuan CWB1 (580018.SH), listed in Shanghai Stock Exchange on February 26, 2008, was a call contract maturing on August 25, 2009. The last trading day is August 18, 2009 (7 calendar days before maturity). The warrant could be exercised during the period August 19, 2009 through August 25, 2009. The initial strike price of ZhongYuan CWB1 was 40.38 yuan with an exercise ratio of 0.5, i.e., holding one warrant provided the right to buy 0.5 share of the

[29] On December 7, 2016, the company officially changed its name to "COSCO SHIPPING Specialized Carriers Co Ltd."

[30] The Chinese name of the company was Zhong Yuan Hang Yun.

underlying stock, the Zhong Yuan Hang Yun (600428.SH). According to the rules set by SSE, the strike price and the exercise ratio were to be changed if the underlying stock paid dividends or split its stock (please refer to Appendix A for details). In our case, the underlying stock 600428.SH paid dividends twice during the lifetime of the warrant 580018.SH: the first ex-dividend day was May 22, 2008 (with a cash dividend of 0.7 CNY per share), and the second was September 23, 2008 (2-for-1 split accompanied by a cash dividend of 0.2 CNY per share). Accordingly, from May 22, 2008, the strike price was 39.66 yuan, and the exercise ratio was 0.5; from September 23, 2008, the strike price was 19.26 yuan, and the exercise ratio was 1.01.

Due to the price limit rule in the stock market, we can show that, given the closing price of the underlying asset, the day-end maximum payoff for warrant 580018 on its last trading day is zero.[31] However, the closing price of the warrant on its last trading day was 0.957 yuan, and the minimum trading price during the last trading day was 0.831 yuan! Figure 7 shows the intra-day trading of ZhongYuan CWB1 during its last three trading days. We can see that, investors conducted unsophisticated trades in the deep OTM warrant: trading was halted twice during the last two trading days because of a sudden price rise before each suspension.

Investors became frenzied during the last trading day in that warrants with a day-end fundamental value of exactly zero were turned over at a 1700% rate, with prices over 0.8 yuan. Noting that this is the last trading day, investors, especially those who held the warrant till the end of the day, indulged in an extreme version of irrational speculation. In fact, anecdotally, during this "Last-Trading-Day" frenzy, out-of-the-money expired warrants experienced frantic trading frenzy during their last few trading days in many instances and the turnover ratio exceeded hundreds of percent on several occasions. Figure 5 provides evidence on this issue.

[31] From the appendix, it follows that the day-end maximum payoff on the last trading day is $\max(0,\ 11.71 \times (1 + 0.1)^5 - 19.26) \times 1.01$, where 11.71 is the closing price of its underlying on the last trading day, 19.26 is the strike price, 0.1 is the maximum daily return in the Chinese stock market, 5 is the number of trading days remaining till maturity, and 1.01 is the exercise ratio.

We attribute this behavior to the notion that who hold warrants after the market closing of the last trading day treat warrants as stocks. Indeed, after the market close on the last trading day, there are investors who ask questions on bulletin boards like "will my warrants become worthless tomorrow?", "why is trading [in warrants] suspended?", "will the warrant disappear forever?", etc., indicating their unawareness of the role of maturity. Figure 8, a screen shot from one of the most famous stock forums in China, offers more interesting details about investors' lack of knowledge on the mechanism of warrant trading.

The case of ZhongYuan CWB1 demonstrates how naïve investors forfeit their investment by paying positive prices for surely worthless warrants.[32] The ZhongYuan CWB1 is not alone, however. There are several other warrants in which a similar phenomenon occurs. Table 11 reports the trading summaries for 17 warrants that have a guaranteed zero payoff at market close on their last trading day.[33] Table 11 reveals that for 11 warrants, the closing prices and the lowest trading prices on their last trading day are lower than or equal to 0.01 yuan, and that for 8 warrants, the highest trading prices are higher than 0.25 yuan. As a result, the volume-weighted average trading price on the last trading day ranges from 0.007 yuan to 1.438 yuan, and the corresponding trading volume is huge! In the last five columns of Table 11, we report the distribution

[32] Nonetheless, there are some investors who can make money by conducting day trades. In unreported analyses, we find that, on the last trading day, there is (only) one institution who conducts four trades and earn net profit of 267 yuan. Also, among those top 0.1% investors, twelve investors trade 264 times and earn a net profit of 0.22 million yuan. As a matter of fact, both the institution and those twelve investors from the top 0.1% group clear their warrant position before the market closing of the day.

[33] In addition, there are 15 warrants that have a guaranteed zero payoff before market opening on at least one trading day. Table OA.1 in the online appendix reports the details. Also, another relevant concern is that holding a worthless warrant is not necessarily irrational if it is not possible to trade its underlying at the daily limit price. However, for all warrants listed in Table 11, their underlyings are tradeable on the day of expiration. There is only one warrant (038004), whose underlying (000858) hit the lower limit on April 1, 2008, which is the trading day right before expiration. Note that the moneyness of the put warrant 038004 at the market closing of its last trading day is -1.527, which means that exercising the warrant is meaningful only if the underlying hits the lower price limit during more than 14 consecutive trading days right after the last trading day ($\log(0.9^{14}) = -1.475$ and $\log(0.9^{15}) = -1.580$) or, in other words, only if the underlying price decreases by more than 77%! The cases for other warrants in Table 11 are similar since all of them are deep OTM at the market closing of their last trading day. Thus, it is a dominant strategy for investors to sell the warrant and buy shares directly through the stock market if they are bullish/bearish about the underlying asset.

of trading volume among different groups of investors during the last trading day. We find that most trading was conducted by individual investors, and that the majority of trading volume is contributed by the bottom 10% of investors (by profitability).[34] These observations are consistent with those reported in Table 9 for all OTM warrants. Given the low commission fee (usually between 0.1% to 0.3% of trading value with a minimum of 5 yuan per trade)[35] and a minimum lot size of 100 shares (see Appendix A), transaction costs are unlikely to explain why these warrants were held (instead of being sold) at close on the last trading day for a guaranteed 100% loss.[36]

It is also of interest to see if there is any evidence of learning. Thus, we wonder if prices of worthless OTM warrants are closer to zero in the latter part of the sample, and if those who erred make the error again. To this end, Panel A of Figure 10 shows, in chronological order, the closing prices and the volume weighted mean prices on the last trading day of all warrants listed in Table 11. As can be seen, there is no clear pattern that prices of OTM worthless warrants are decreasing. Panel B shows that the proportion of old investors (who had ever held warrants till the end of last trading day) that err again is significantly lower than that of old investors (who had ever trade warrants on their last trading day) that trade last-day warrant again. In fact, there are 4,131 investors who had ever hold warrants with guaranteed zero payoff until the end of the last trading day, and only 153 (or 3.7%) of them erred more than once.[37] There are 15,455 investors who had ever traded warrants with guaranteed zero payoff on the last trading day,

[34] Figure OA.5 in the online appendix shows that small investors and those that have suffered greater losses previously have a stronger tendency to hold deep OTM warrants after market closing on last trading day.

[35] A few brokerage houses abolished the restriction of a minimum commission fee per trade for some clients. In our sample, there are 5,990,064 trades (or 28.3%) which have a commission fee of exactly 5 yuan, and 168,960 trades (or 0.8%) with fees lower than 5 yuan.

[36] Unreported results confirm that closing portfolio values on the last trading day commonly exceed the minimum commission fee of 5 yuan per trade. Taking 580018 and 580997 as representative, the closing price for warrant 580018 (580997) on its last trading day is 0.957 (0.002) yuan. Position values at the end of the last trading day are higher than the minimum commission fee of 5 yuan for more than 99% (60%) of investors that hold warrant 580018 (580997). Figure OA.6 in the online appendix provides the details.

[37] Figure OA.7 in the online appendix shows the distribution of investors by the number of times that investors erred, i.e., held deep OTM expired warrants till the end of the last trading day.

and 2,183 (or 14.1%) of them traded at least two different warrants with guaranteed zero payoffs on their last trading day. However this low proportion (3.7%) of investors who err more than once does not necessarily mean that investors learn efficiently. In Panel C, we split investors who trade the current warrant on its last trading day into two groups. The first group, which we term new investors, consists of investors who never hold previous warrants till the end of their last trading day. The second group, which we term old investors, consists of those who had ever hold previously expired warrants till the end of last trading day at least once. A statistical test is not able to conclude that the proportion of investors err among the group of old investors is lower than that among new investors.[38]

The empirical evidence in this section is consistent with the theoretical implications of Carlin (2009) that complexity can prevent prices from converging to fundamentals despite the existence of a large number of suppliers. The results also support the notion that retail investors' financial literacy has lagged behind the ever-increasing complexity of financial products, but they nonetheless choose to participate in the market for complex assets (Carlin and Manso 2011). The fact that many investors in the warrants market could not fully comprehend simple concepts like maturity and strike price is also related to the emerging literature on financial literacy: Lusardi and Mitchell (2014) and Keys, Pope, and Pope (2016) show that low levels of financial knowledge incur significant losses for households.[39]

[38] Figure OA.8 in the online appendix shows that super investors (top 0.1% in terms of value per trade), the most profitable investors (top 0.1% in terms of net profit), and institutional investors do not make the same mistake (of holding worthless warrants after expiration) more than once.

[39] Lusardi, Michaud, and Mitchell (2017) embed financial knowledge into a stochastic life cycle model and show that the new model can generate higher level of wealth inequality than some classical models and that financial knowledge and lack thereof can account for more than 30% of retirement wealth inequality.

5.2 Trading Mechanisms Revisited

Another interesting phenomenon from the middle panel of Figure 7 is that, during the last 20 minutes on the penultimate trading day, the trading price stays at the level of 2.203 yuan, and the trading volume suddenly decreases to a very low level. This phenomenon is caused by the price limit rule in the Chinese *warrant* market. Under the rule, any order with price lower than the lower price limit cannot be submitted or executed. Figure 9 shows order book data during this period. The low trading volume, together with the high volume at the best ask (which equals the lower price limit) in this period, indicates that the majority of investors believe the price should decrease to a lower level. In fact, the maximum possible payoff at the end of the penultimate trading day is 1.20 yuan. However the lower price limit on the same day, which is 2.203 yuan in this case, prevents the warrant price from falling to a lower level.

Recall the formula in Appendix A that, subject to a rounding error, the daily price limit of a warrant on day $t+1$ can be written as

$$\left[\underline{W}_{t+1} \triangleq \max\left(0,\, W_t - S_t \times 0.1 \times 1.25 \times ER\right), \quad \overline{W}_{t+1} \triangleq W_t + S_t \times 0.1 \times 1.25 \times ER\right], \qquad (1)$$

which is determined by the closing price W_t of the warrant, the closing price S_t of its underlying asset on the previous trading day t, and the exercise ratio ER.[40] It is easy to see from Eq. (1) that, if a deep OTM warrant is significantly overpriced and its underlying price is very low, i.e., when W_t is large and S_t is small, the lower limit $\underline{W}_{t+1}$ defined here can be well above 0. These assumptions are easily satisfied by many deep OTM *call* warrants. For these warrants, the trading mechanism can prevent warrant prices from falling to zero, since any trading below the lower price limit $\underline{W}_{t+1}$ is prohibited.

[40] ER is the number of shares of the underlying stock one can buy or sell when holding 1 warrant.

Table 12 reports the number of trading days (out of their last 20 trading days) on which warrants' lower price limit for trading is higher than their day-end theoretical prices.[41] When we use Black-Scholes prices as fundamentals (the column N_{BS1}), there are 8 warrants for which, on more than ten trading days during a 20-day period, the lower price limits are strictly higher than the corresponding fundamental values. When we double the volatility parameter, which results in unreasonably high volatilities and thus significantly increases the theoretical values, the numbers (in column N_{BS2}) only slightly decrease for most warrants.[42] When we use a more extreme value, i.e., the warrant's maximum payoff, as a proxy for the theoretical price, there are still ten scenarios in which the lower price limit is higher. It is reasonable to conjecture that even the regulators in the warrants market did not fully understand the contract and properly anticipate the trading behavior of market participants. Specifically, while price limits are supposed to protect investors from market manipulation (Brennan 1986; Kim and Park 2010), in this particular instance, the limit completely prevented the convergence of prices to fundamentals on occasion and ended up facilitating investors' underperformance.

5.3 Learning from Experience: A Followup Options Market in China

The previous analysis indicates that phenomena in the warrants market were not consistent with agents comprehending derivatives and trading them rationally. Further, Figure 10 indicates that it may not be desirable to depend wholly on investors' learning via trading (Nicolosi, Peng, and Zhu 2009) for markets to speedily reach maturity. Given this observation, how might exchanges prevent such episodes from recurring in the future? Some insights on these issues can be obtained by considering the case of a next-generation options market in China.

[41] Using theoretical prices at the end of the previous trading day results in qualitatively similar results. Please refer to Table OA.2 in the online appendix for details.

[42] Since the goal of the split-share reform is to convert non-tradeable shares to tradeable ones (see, e.g., Gong, Pan, and Shi 2017), no brand new shares are issued when warrants are exercised. As such, there are no dilution effects.

Specifically, on February 9, 2015, China launched a new class of options on the Shanghai Stock Exchange (SSE).[43] The options were based on the exchange-traded fund (ETF) that tracks the blue-chip SSE50 index, composed of the 50 largest publicly traded stocks on the bourse.

Due to the painful experience in the prior warrants market, China started the new market gingerly. All individual investors were required to pass three progressive examinations (concerning knowledge of options and typical options strategies) before they qualified for options trading.[44] The SSE required all options trading operators to conduct regular investor education. These requirements minimized the likelihood of investor naïveté driving prices.

Beyond the above programs, the SSE also mandated that individual investors' balance (including cash and shares) in their trading account should be no less than 500,000 Chinese yuan,[45] and all individual investors were required to have prior experience of futures trading or margin trading. These strict access conditions are consistent with the insights provided in Brunnermeier and Oehmke (2009) that one way to deal with the complexity (in financial markets) is to restrict the set of qualified investors. The practice is also consistent with the empirical findings showing that a financial education program may have modest effects on financial behavior (Cole, Sampson, and Zia 2011) and that mere availability of unbiased financial advice is not sufficient for benefiting retail investors (Bhattacharya et al. 2012). The constraint on total account balance further limits the likelihood of errant prices, given earlier findings that the proportion of agents that err tends to be higher among small investors (see Figures OA.5 and OA.8 in the online appendix).

The exchange also introduced fifteen designated market makers and imposed many strict

[43] This is the first exchange traded stock option market launched in China after the last exchange traded warrant (ChangHong CWB1, 580027) expired on August 11, 2011.

[44] The three progressive exams correspond to three levels of qualifications for options trading: a level one qualification allowed using options to hedge (sell calls or buy puts when holding enough underlyings); level two allowed for taking long options positions regardless of investors' underlying position; and level three investors qualified for all possible options trading strategies regardless of investors' underlying position.

[45] Although China has around 50 million active equity trading accounts, only about 5% of them meet this criterion. As of the end of 2016, 202,013 investors (including 3518 institutions) had opened options trading accounts. Further details are available in the annual SSE Factbooks at http://www.sse.com.cn/aboutus/publication/factbook/.

rules and evaluation criteria for these traders.[46] Note that designating market makers and evaluating them circumscribes the likelihood that options might be traded at clearly irrational prices. Thus, quoting a positive ask for a surely worthless option doubtless would attract regulator scrutiny, and also would run the risk that the market maker would end up with a positive inventory of that option, as the dealer of last resort.

Subsequent to the implementation of the above features, the current options market in China functions relatively smoothly. Figure OA.9 in the online appendix shows that most trading in this market occurs when close to ATM, trading volume decreases steadily as deep OTM expired options approach maturities, and trading prices of deep OTM expired options are vanishingly small in the few days before expiration. All these phenomena are what would be expected in a mature options market.

In this newer market, there is a price limit rule[47] similar to to that used in the earlier Chinese warrants market; see Eq. (1) in Section 5.2. Thus, the lower price limit continues to be problematic for potentially overvalued deep OTM call options. However, as shown in Figure OA.9 in the online appendix, prices and trading volume in the market are at sensible levels. In particular, the bottom plot in Figure OA.9 shows that trading frenzies in deep OTM warrants revealed within Table 11 are absent from this market[48] and, since deep OTM call options are not materially overpriced, we do not observe cases like those exhibited in Table 12 in the market.

[46] Although the SSE allowed a group of qualified brokerage firms to originate (create) additional shares for some warrants, there was no designated market maker in the Chinese warrants market. The market makers in the new options market are usually responsible for providing double-sided (both buy and sell) quotes. There also are constraints on maximum bid-ask spreads, minimum quote size, the minimum fraction of coverage (of different option contracts), the maximum response time (after receiving a request for quotation), etc. The SSE conducts an annual evaluation on market making quality of all market makers. Depending on results, market making privileges are liable to be cancelled.

[47] See www.sse.com.cn/assortment/options (in Chinese). The lower price limit $\underline{O}_{t+1}$ for both calls and puts is $\underline{O}_{t+1} \triangleq \max(0.0001, O_t - S_t \times 10\%)$, where O_t is the option's settlement price at market close on day t, S_t is the closing price of the underlying asset, and 0.0001 is the minimum tick size for options quotes.

[48] Unreported analyses indicate that there are some trades in worthless options, but the trading volume is very low and the corresponding trading prices are only a few basis points.

Overall, the improved performance of the follow-up options market clarifies features (i.e, the afore-mentioned investor education requirements, screening based on investor sophistication proxies, and designated dealers) that enhance smooth functioning of markets for assets with complex payoffs.

6 Conclusion

A major focus of the behavioral finance literature is the issue of whether agents exhibit biases while investing in simple securities (such as equities), for example, due to overconfidence or loss aversion (Barber and Odean 2000, Barberis and Huang 2001). We analyze a related issue: Do agents comprehend the payoff functions associated with more complex securities such as options, as is assumed in no-arbitrage settings? Further, why and how do investors profit in nascent markets for such securities? We address these questions in the context of an episode in China, wherein equity investors obtained access to warrants as a result of regulatory reform. That there were no prevailing options markets at the time of the warrant issuance makes this event particularly useful in analyzing whether investors are able to understand the basics of unfamiliar contracts during the initial stage of the derivative market's evolution.

Using a proprietary brokerage account dataset, we provide evidence that investors trade warrants with high ex ante skewness and also pay for high skewness. The effect is much more salient for individuals than that for institutions. In fact, we find that institutions can earn money by trading warrants with high ex ante skewness. However, institutions are not systematically more smart than individuals: there are several naïve institutions as well. On average, individuals earn profits by holding warrants with lower skewness interday, but suffer adverse performance by conducting intraday trading; while institutions' profits are mainly due to intraday trading of

warrants with high skewness. The top (in terms of total net profit) 0.1% investors trade extremely actively and hold the least amount of warrants interday. The behavior of the extremely active top investors indicates that their profitability is mainly due to their trading skills rather than their informational advantages.

We further find that quite a few investors are challenged in their understanding of options: they simply treat warrants as common equity, because they act as though complete forfeiture of investment is unlikely, as in the latter class of securities, rather than highly likely, as in the former class. Specifically, investors hold deep OTM warrants till maturity and/or even adopt a so-called "doubling" strategy as warrants approach their maturities. Several investors pay positive prices for derivatives that guarantee a reduction in invested capital owing to price limits in the underlying asset market. Our additional consideration of the price-limit rule in the *warrant* market indicates that even regulators exhibit a lack of familiarity with the warrant market in that price limits bounds preclude the convergence of warrants to fundamental values. We thus emphasize the importance of ensuring financial sophistication in derivatives markets.[49]

Bali and Murray (2013) and Boyer and Vorkink (2014) find a strong and negative relationship between options' skewness and subsequent realized returns, suggesting investors overpay for skewness in derivatives. Chang et al. (2013) and Tang and Wang (2013) document that stylized relations between Chinese warrant prices and its underlying asset do not support theoretical monotonicity and correlation patterns across warrants and the underlying shares. By taking advantage of brokerage account data, our paper complements these studies by showing that limited investor knowledge about derivatives (in particular, conflation of contingent claims with equities) also contributes materially to trading performance in these derivatives markets.

[49]The notion of nominal price illusion studied in Birru and Wang (2016) could also play an important role since OTM warrants have very low prices when they are close to maturity.

Appendix

A Institutional Details of the Chinese Warrants Market

In China, the trading mechanism of warrants is very much like that of stocks. For example, investors can trade warrants using their stock accounts, and the lot size (the minimum unit for submitting orders) of trading both stocks and warrants is 100 shares. But there are some differences, which are listed below:

(1) Risk Disclosure: After August 1, 2007, each investor is required to sign a "Warrant Risk Disclosure Letter" in written form, which indicates that the investor fully understands the risks of warrant trading.

(2) Tick Size: Since the warrant could be worth as low as zero, the minimum tick size for warrant trading is set as CNY 0.001, which is one-tenth of that (CNY 0.01) for stock trading.

(3) Price Limit: both the Chinese stock and warrant markets have adopted price-limit rules,[50] so that only orders with prices within some pre-specified ranges can be submitted and executed.

   (i) Stock market: the maximum daily price change is 10%, i.e., the trading prices on day $t+1$ are limited to the interval $\left[\underline{S}_{t+1} \triangleq S_t \times (1-10\%),\ \ \overline{S}_{t+1} \triangleq S_t \times (1+10\%)\right]$, where S_t is the closing price of the same stock on day t. By convention, $\underline{S}_{t+1}$ and $\overline{S}_{t+1}$ are rounded to the tick size for stocks, i.e., CNY 0.01.

   (ii) The price limits for warrant trading are computed by considering absolute prices rather

[50] All trading rules are set by the relevant exchanges and approved by China Securities Regulatory Commission (CSRC).

than percentages: the trading prices of warrants on day $t+1$ are limited to the interval

$$\left[\underline{W}_{t+1} \triangleq \max\left(0,\, W_t - (S_t - \underline{S}_{t+1}) \times 1.25 \times ER\right),\ \ \overline{W}_{t+1} \triangleq W_t + (\overline{S}_{t+1} - S_t) \times 1.25 \times ER\right],$$

where W_t is the closing price of warrant on day t, $\underline{S}_{t+1}$ and $\overline{S}_{t+1}$ are the price limits of the underlying stock on day $t+1$, and ER is the exercise ratio[51] of the warrant. Again, by convention, $\underline{W}_{t+1}$ and $\overline{W}_{t+1}$ are rounded to CNY 0.001, the tick size of warrant trading.

(4) Intraday Trading: In China, the stock market adopts a so-called "T+1" mechanism, i.e., the stocks bought on day t can only be sold out on or after day $t+1$. But the warrant market adopted the "T+0" mechanism: investors can sell the warrant they buy in the same day.

(5) Order Quantity: The quantity of each order cannot be more than 1 million shares.

(6) Stamp Tax: Warrant trading was not subject to a stamp tax. Stock trading, however, is subject to a stamp tax of 0.1% before May 30, 2007, of 0.3% on and after May 30, 2007, of 0.1% on and after April 24, 2008, and of 0.1% for sell only on and after September 19, 2008.

(7) The rules governing changes of strike price and exercise ratio for warrants were as follows:

(i) When the underlying undergoes a stock split on day t, $Strike\_Price_{New} = Strike\_Price_{Old} \times \frac{RefP_t}{CloP_{t-1}}$, and $Exercise\_Ratio_{New} = Exercise\_Ratio_{Old} \times \frac{CloP_{t-1}}{RefP_t}$, where $RefP_t$ denotes the reference price of the underlying on day t, and $CloP_{t-1}$ the closing price on day $t-1$.

(ii) When the underlying pays cash dividends on day t, the exercise ratio remains unchanged, and $Strike\_Price_{New} = Strike\_Price_{Old} \times \frac{RefP_t}{CloP_{t-1}}$.

[51] The shares of stock one can buy or sell upon exercise of each warrant.

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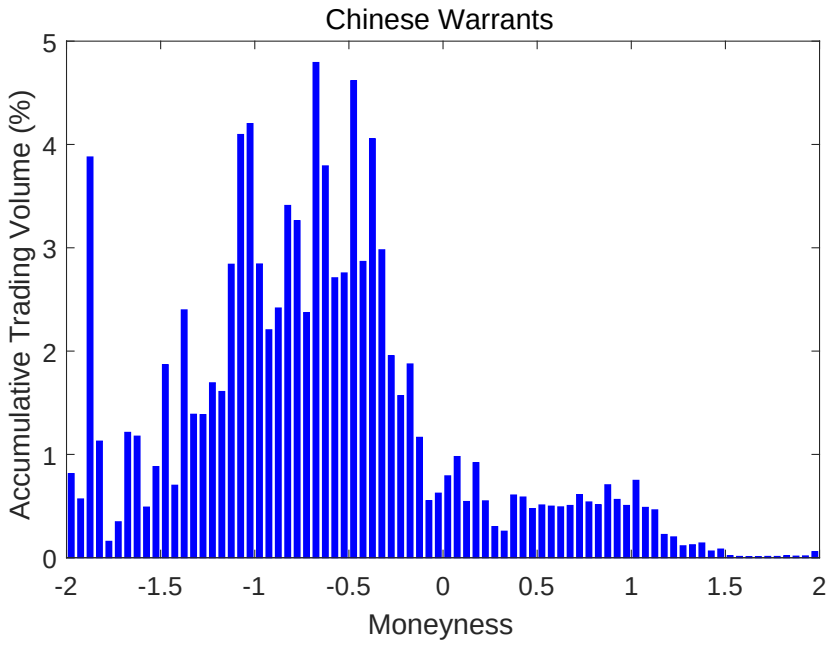


Figure 1: Trading Volume in Chinese Warrants Market by Moneyness. This figure shows the aggregated trading volume in each bin of moneyness. The figure only accounts for warrant trading in our proprietary dataset. Here we define moneyness as $\log(S_t/K)$ for calls, and as $-\log(S_t/K)$ for puts, where K is strike price and S_t is underlying price. The bin size for moneyness is 0.05.

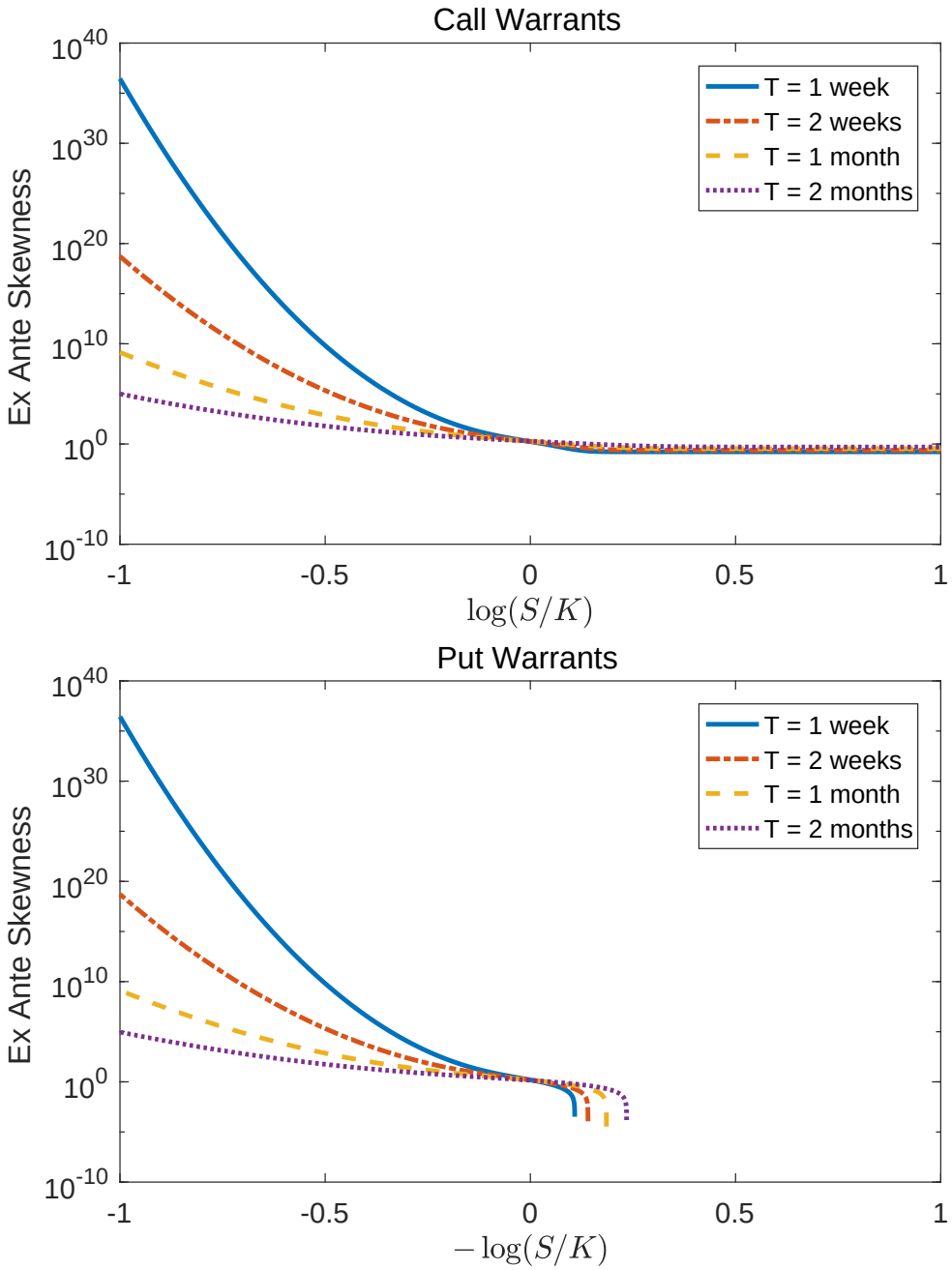


Figure 2: Ex Ante Skewness of Warrant Return vs. Moneyness. This figure shows warrant returns' ex ante skewness as a function of moneyness. We define moneyness as $\log(S/K)$ (resp. $-\log(S/K)$) for calls (resp. puts), where K is the strike price and S is the underlying price. We assume the expected return of the underlying stock is 8%, return volatility is 40%, and the risk-free rate is 3%. To exhibit the plots more clearly, we use a log-scale for the y-axis.

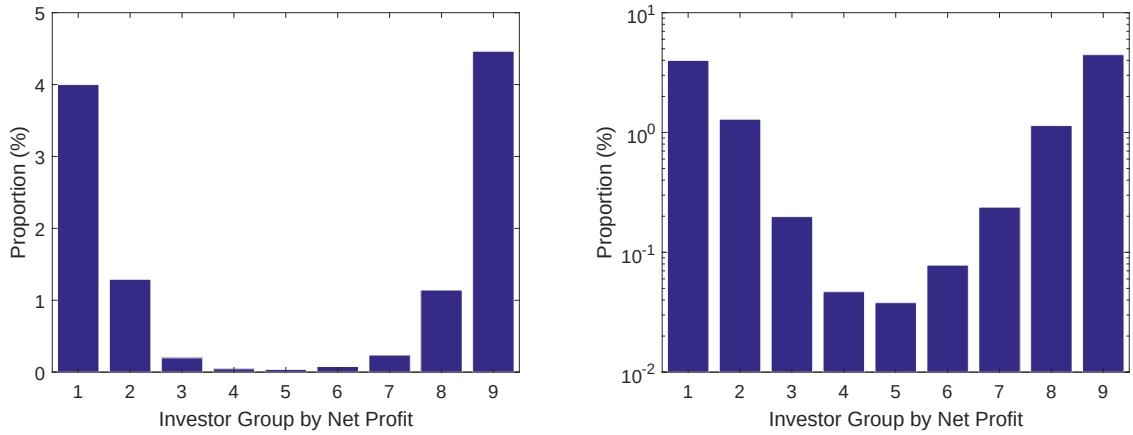


Figure 3: Proportion of institutional investors in each group of investors (grouped by their total net profits). We sort all investors by their total net profits, then we divide them into nine groups, which contain investors belonging to the top 0.1% (group 1), 0.1% ∼1%, 1%∼10%, , 10%∼30%, 30%∼70%, 70%∼90%, 90%∼99%, 99%∼99.9%, and the bottom 0.1% (group 9), respectively. The left panel shows the proportion of institutional investors in each group. The right panel shows the same results under the log scale for the y-axis.

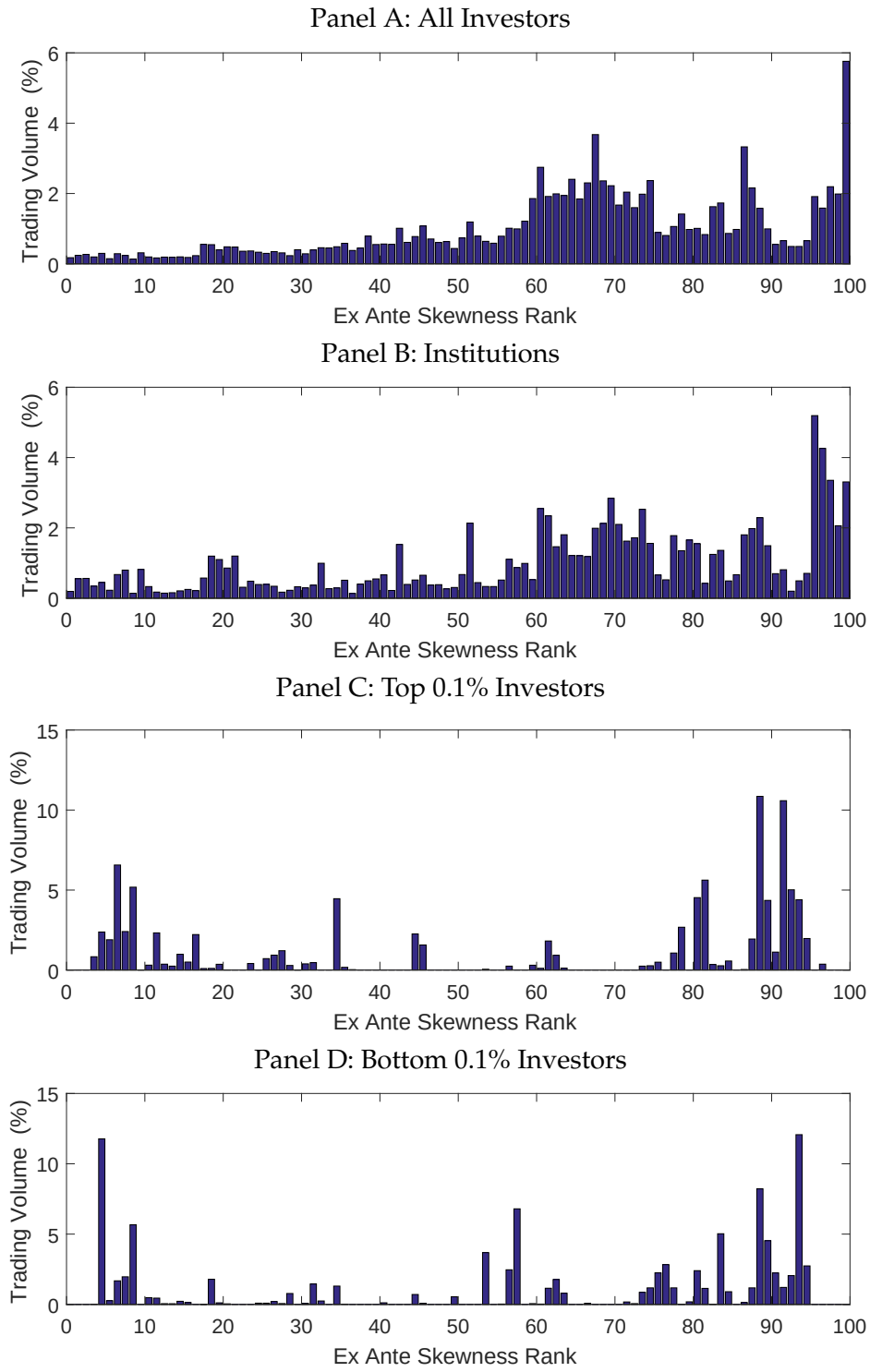


Figure 4: Trading Volume by Ex Ante Skewness. This figure shows the aggregated trading volume in each bin of ex ante skewness. We separate skewness bins by percentiles. From top to bottom, respectively, the four plots show results for all investors, for institutions, for top (in terms of total net profit) 0.1% investors, and for bottom 0.1% (in terms of total net profit) investors.

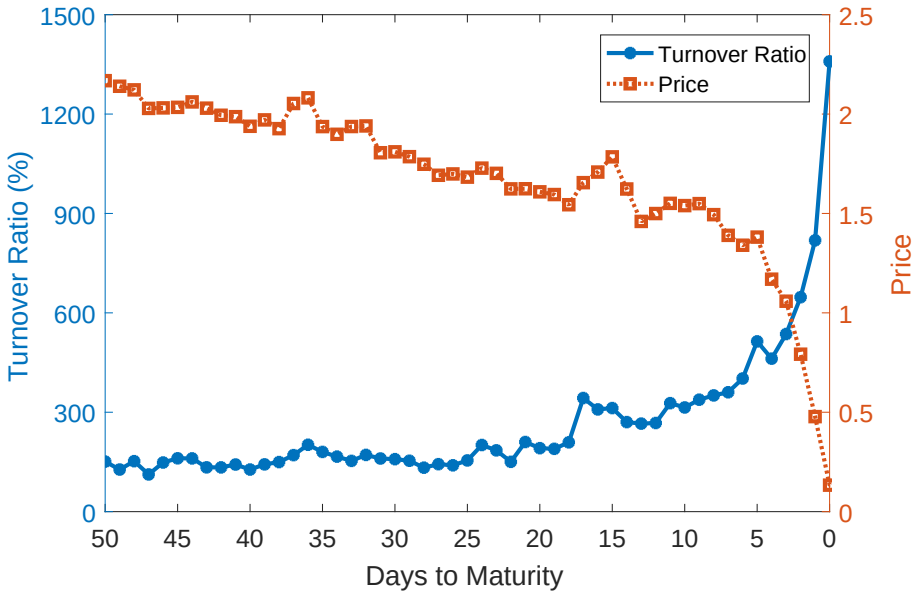


Figure 5: Price and Turnover Ratio by Date for OTM Expired Warrants. This plot shows the average price and average turnover ratio versus the number of trading days to maturity for all OTM (as per the moneyness on the last trading day) expired warrants in our sample.

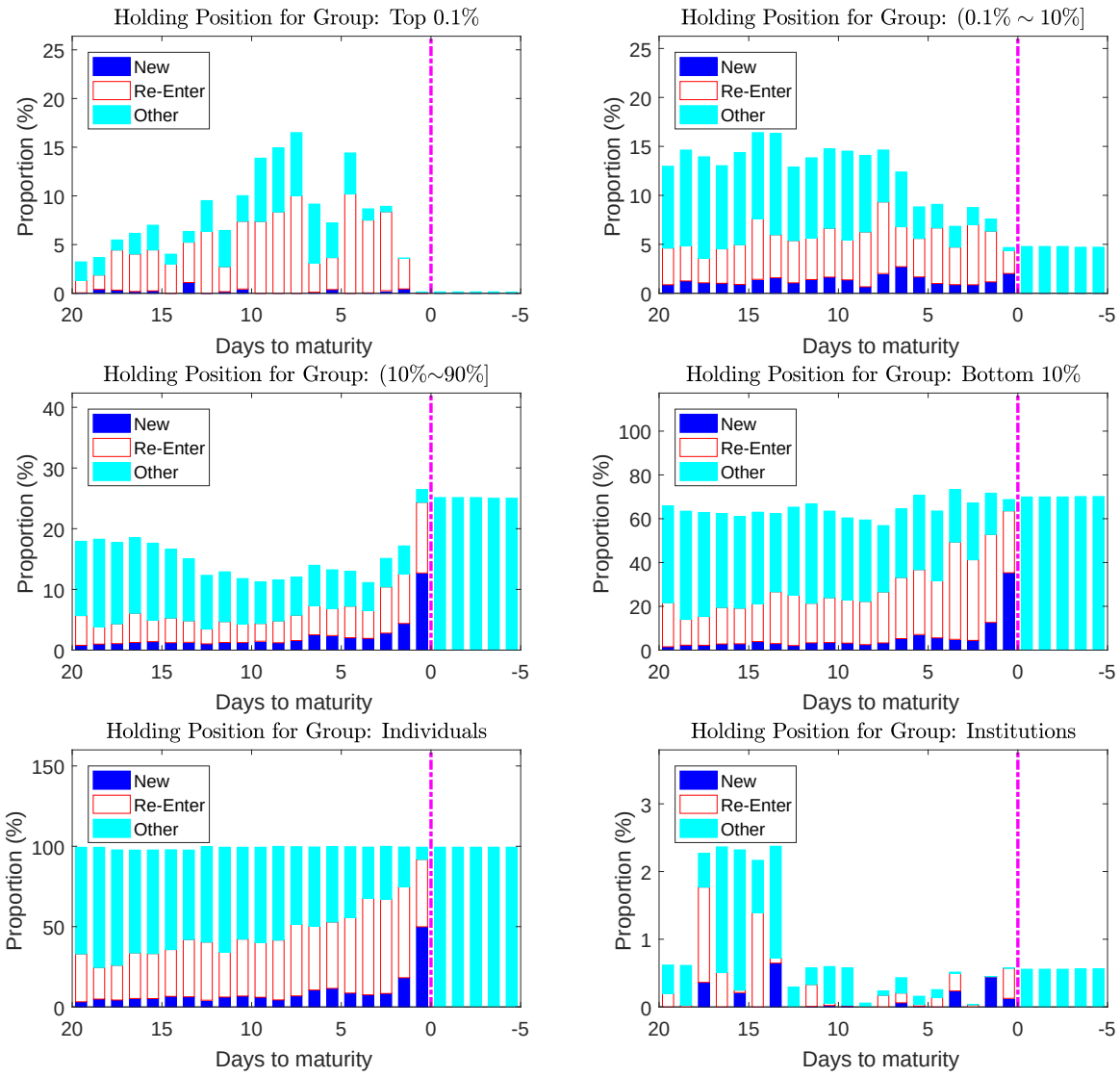


Figure 6: Day End Holding Position in OTM Warrants during the Last 20 Trading Days. This figure shows the proportions of aggregated day-end holding positions in all OTM (as per the moneyness at the last trading day) warrants for different profitability groups (top 0.1%, 1‰ ∼ 10%, 10% ∼ 90%, and bottom 10%), and for individuals and institutions separately. On each trading day, we split holding positions into three parts: the first (New) consists of positions held by new investors (investors that first trade the specific warrant on that day), the second (Re-Enter) is the sum of net daily position changes by existing investors who increase positions on that day, and the third (Other) includes the remaining positions.

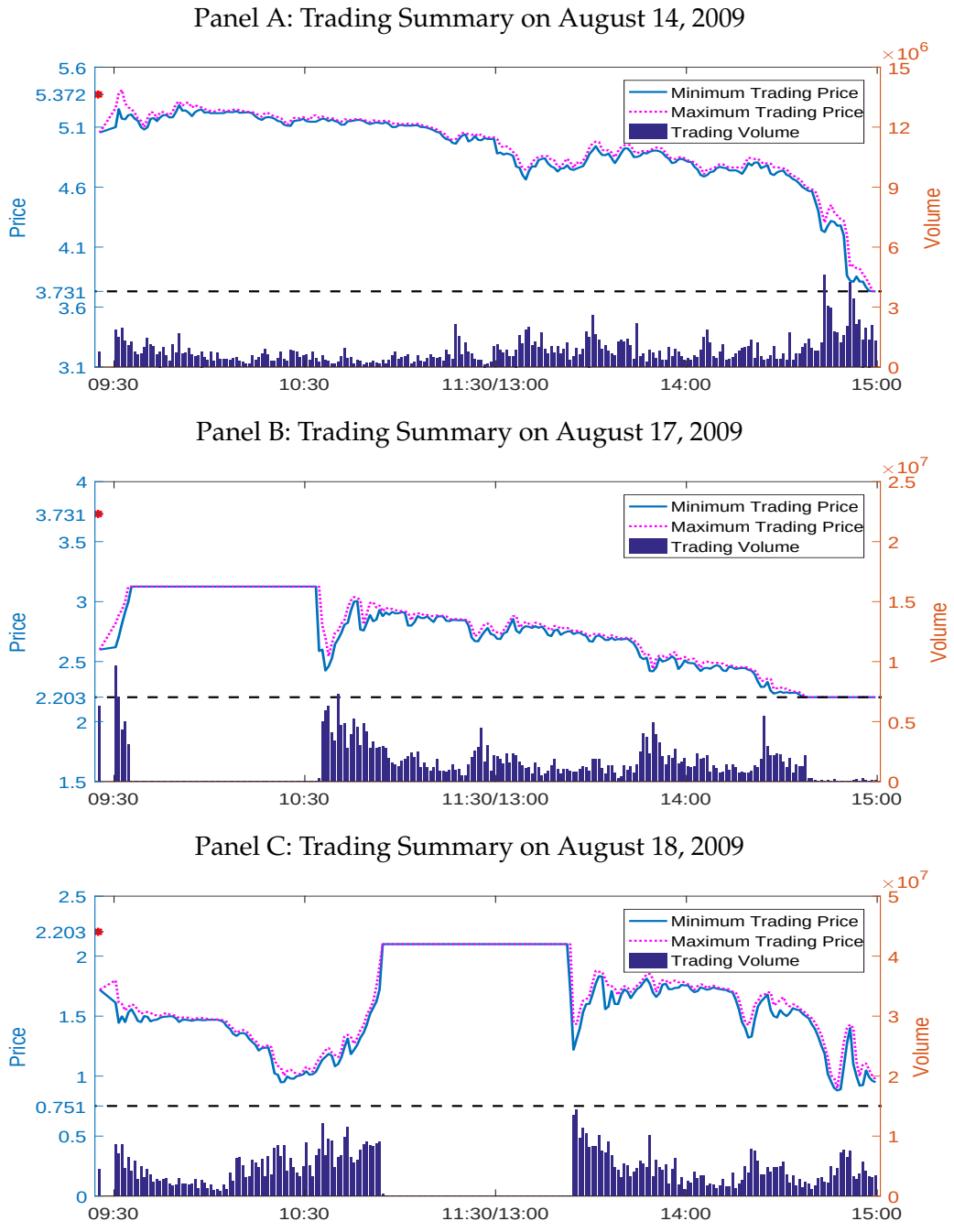
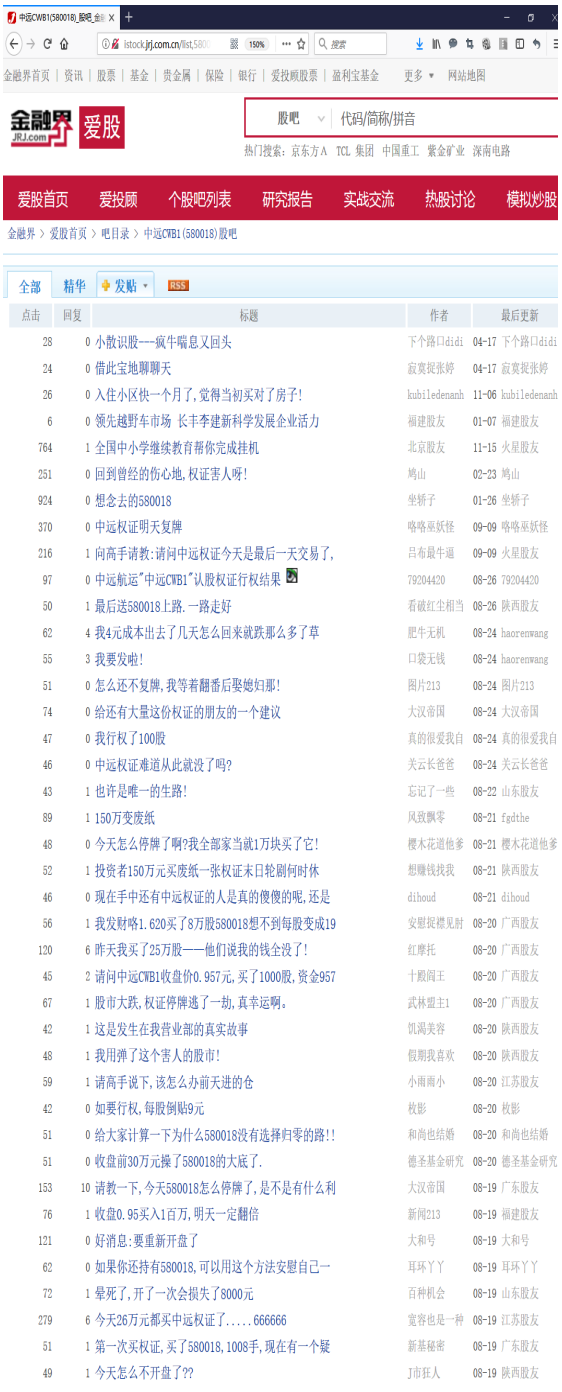


Figure 7: Trading in Warrant 580018 During Its Last Three Trading Days (August 14/17/18, 2009). We plot the minimum trading price, the maximum trading price, as well as the trading volume in each minute. The closing price in the previous trading day is marked by an asterisk. The dashed line in each plot represents the lower price limit on that day. According to the "Guidance for real-time monitoring of abnormal security trading" published by the Shanghai Stock Exchange (version May 14, 2008), the trading of 580018 was halted from 9:35am to 10:34am on August 17 and from 10:54am to 13:23pm on August 18, due to the sudden price rise right before each suspension.



English translation
Zhongyuan CWB1 will resume trading tomorrow
Slumped so much in past several days? Dang it!
I will make a fortune!
Why doesn't it resume trading? I will get married after the value (of my warrants) doubles!
I exercised 100 shares.
Will this warrant disappear forever?
Why is the trading [in warrants] suspended?
I will make a fortune: I bought 80,000 shares at 1.620, now it is at 19! [In fact, the *strike* price is 19]
The stock market has crashed. We are lucky since the warrant's trading is suspended.
I bought CNY 0.3 million worth of warrants near market closing.
Why is the trading suspended? Any good news?
Bought 1 million at 0.95. Must be doubled tomorrow!
Good news: [the warrant] will resume trading.
Invested 0.26 million in the warrant today ..... awesome!
Why isn't the [warrant] market open today??

Figure 8: Screen Shot of an Online Forum on Warrant 580018. This figure shows a screen shot of the web page `http://istock.jrj.com.cn/list,580018,p1.html`, which is a forum on warrant 580018. The last trading day is August 18, 2009, and its maturity day is August 25, 2009. We translate some interesting and relevant posts to English on the left hand of the picture. Each translation starts from the same line as the Chinese title of the post. The contents in square brackets are our notes.

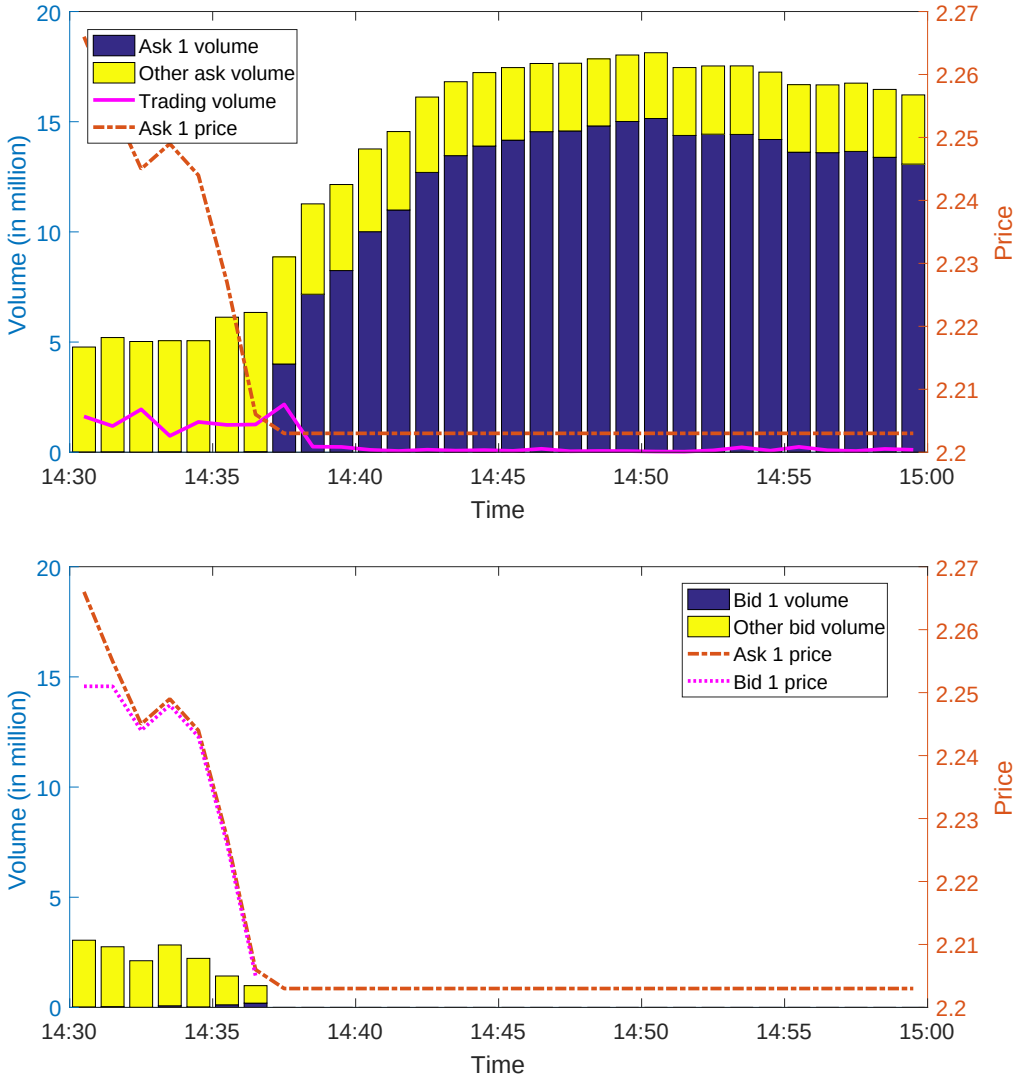


Figure 9: Order Book and Trading Data for Warrant 580018. This plot shows end-of-minute best ask volume, other ask volume, best ask price, best bid volume, other bid volume, best bid price, and trading volume in each minute, for warrant 580018 during the last 30 minutes on its penultimate trading day. Volume is measured in millions of shares. On the figure, bid/ask "1 price" means the best bid/ask price. After the ask 1 price reaches the lower price limit of 2.203 yuan, the total bid volume becomes zero and bid prices are unavailable, since investors cannot submit buy orders with prices lower than 2.203 yuan.

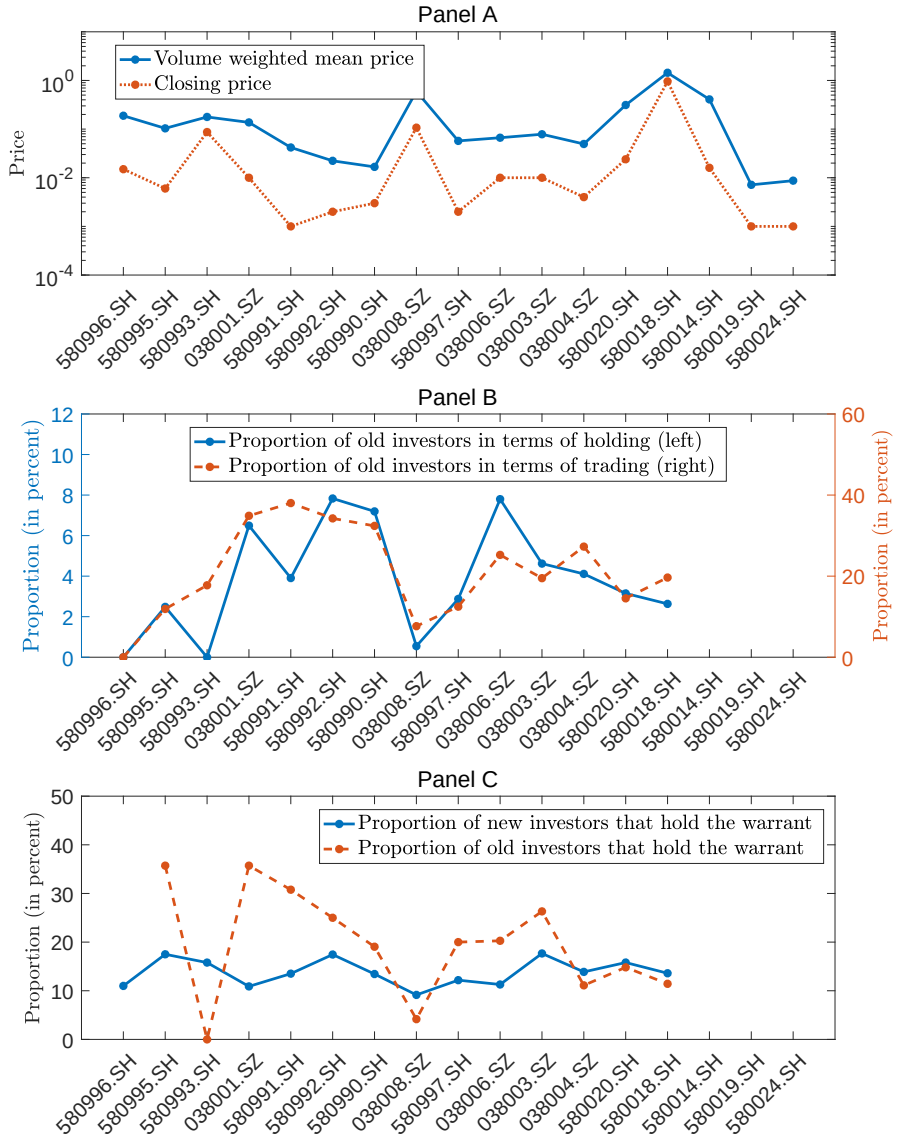


Figure 10: Prices and investors' behavior in the last trading day for warrants with guaranteed zero payoff. We sort warrants in Table 11 by chronological order of their last trading day. Panel A reports closing prices and volume weighted mean prices on the last trading day for each warrant. Panel B reports, for each warrant's trading on the last day, the proportion of investors that had ever traded previously expired warrants on their last trading day, and that of investors who had ever held previously expired warrants till the end of their last trading day. In Panel C, we split investors who trade the warrant on its last trading day into two groups. The first group, which we term new investors, consists of investors who never hold previous warrants till the end of their last trading day. The second group, which we term old investors, consists of those who had ever held previously expired warrants till the end of last trading day at least once. Then for each group, we report the proportion of those who hold the current warrant till the end of its last trading day. In Panel C, the two sample t-test cannot reject the null of no difference between sample means at the 5% level.

Table 1: **Meta Information for All Warrants**

This table reports, for each warrant, its name, code, underlying stock's code, type, source, the number (in millions) of circulating shares offered at the beginning, the maximum number of circulating shares during its lifespan, initial reference price (IRP), moneyness (Money= $\log[S_T/K]$ for calls; Money= $-\log[S_T/K]$ for puts) on the last trading day; and its trading period and exercise period. Our dataset spans January 04, 2007 to October 16, 2009, which includes 678 trading days in total. There were 48 warrants (written on 41 different underlying stocks) traded during this sample period. The first 13 warrants were traded in the Shenzhen Stock Exchange, and the remaining 35 warrants were listed in the Shanghai Stock Exchange. Almost all warrants are physically settled; the only exception is warrant 580989, which is cash-settled. There is only one warrant (580007) which has a "put provision": during the exercise period, warrant holders has the additional right of selling their warrants back to issuer at price 1.8 CNY per share. During initial issuance, all warrants are dispatched to qualified investors either as compensation of split-share structure reform (Source equals 1), or in the form of separable warrant-bonds (Source equals 0). For some warrants (those with MShare>Share), the Shanghai Stock Exchange allows a group of qualified brokerage firms to originate (create) additional shares.

									Trading Period		Exercise Period	
Name	Code	Stock	Type	Source	Share	MShare	IRP	Money	Begin	End	Begin	End
WuLiang	030002	000858	Call	1	298	—	0.889	1.666	04/03/2006	03/26/2008	03/27/2008	04/02/2008
QiaoCheng	031001	000069	Call	1	145	—	11.219	2.156	11/24/2006	11/16/2007	11/19/2007	11/23/2007
GangFan	031002	000629	Call	0	800	—	1.216	0.991	12/12/2006	12/04/2008	11/28/2008	12/11/2008
ShenFa	031003	000001	Call	1	155	—	11.472	0.660	06/29/2007	12/21/2007	11/19/2007	12/28/2007
ShenFa	031004	000001	Call	1	78	—	12.819	0.100	06/29/2007	06/20/2008	05/16/2008	06/27/2008
GuoAn	031005	000839	Call	0	96	—	6.352	0.062	09/25/2007	09/17/2009	09/11/2009	09/24/2009
ZhongXing	031006	000063	Call	0	65	—	10.216	0.007	02/22/2008	02/05/2010	02/01/2010	02/12/2010
EJiao	031007	000423	Call	1	131	—	16.132	1.259	07/18/2008	07/10/2009	07/13/2009	07/17/2009
GangFan	038001	000629	Put	1	233	—	1.526	-1.222	11/04/2005	04/24/2007	05/08/2007	05/08/2007
HuaLing	038003	000932	Put	1	633	—	1.161	-0.970	03/02/2006	02/22/2008	02/27/2008	02/29/2008
WuLiang	038004	000858	Put	1	313	—	1.327	-1.527	04/03/2006	03/26/2008	03/27/2008	04/02/2008
ZhongJi	038006	000039	Put	1	424	—	1.026	-1.194	05/25/2006	11/16/2007	11/19/2007	11/23/2007
JiaFei	038008	000792	Put	1	120	—	0.862	-1.097	06/30/2006	06/22/2007	06/25/2007	06/29/2007
BaoGang	580002	600010	Call	1	715	919	0.321	1.078	03/31/2006	03/23/2007	03/26/2007	03/30/2007
HanGang	580003	600001	Call	1	926	1116	0.646	0.914	04/05/2006	03/28/2007	03/29/2007	04/04/2007
ShouChuang	580004	600008	Call	1	60	259	0.475	0.818	04/24/2006	04/16/2007	04/17/2007	04/23/2007
WanHua	580005	600309	Call	1	57	62	8.163	1.804	04/27/2006	04/19/2007	04/20/2007	04/26/2007
YaGe	580006	600177	Call	1	91	253	2.568	1.977	05/22/2006	05/14/2007	05/17/2007	05/21/2007
ChangDian	580007	600900	Call	1	407	—	2.321	0.996	05/25/2006	05/17/2007	05/18/2007	05/24/2007
GuoDian	580008	600795	Call	1	151	255	1.100	1.162	09/05/2006	08/28/2007	08/29/2007	09/04/2007
YiLi	580009	600887	Call	1	111	—	10.510	1.291	11/15/2006	11/07/2007	11/08/2007	11/14/2007
MaGang	580010	600808	Call	0	1265	—	0.708	0.229	11/29/2006	11/14/2008	11/15/2007	11/28/2008
ZhongHua	580011	600500	Call	0	180	—	1.521	1.126	12/18/2006	12/10/2007	12/11/2007	12/17/2007
YunHua	580012	600096	Call	0	54	—	6.619	0.441	03/08/2007	02/20/2009	02/23/2009	03/06/2009
WuGang	580013	600005	Call	0	728	—	3.058	-0.260	04/17/2007	04/09/2009	04/10/2009	04/16/2009
ShenGao	580014	600548	Call	0	108	—	3.341	-0.846	10/30/2007	10/22/2009	10/23/2009	10/29/2009
RiZhao	580015	600017	Call	0	62	—	2.567	-0.322	12/03/2007	11/18/2008	11/19/2008	12/02/2008
ShangQi	580016	600104	Call	0	227	—	8.918	-0.011	01/08/2008	12/30/2009	12/31/2009	01/07/2010
GanYue	580017	600269	Call	0	56	—	3.729	-0.228	02/28/2008	02/05/2010	02/16/2009	02/26/2010
ZhongYuan	580018	600428	Call	0	51	—	5.973	-0.498	02/26/2008	08/18/2009	08/19/2009	08/25/2009
ShiHua	580019	600028	Call	0	3030	—	2.486	-0.541	03/04/2008	02/24/2010	02/25/2010	03/03/2010
ShangGang	580020	600018	Call	0	292	—	1.719	-0.774	03/07/2008	02/27/2009	03/02/2009	03/06/2009
QingPi	580021	600600	Call	0	105	—	2.451	0.073	04/18/2008	10/12/2009	10/13/2009	10/19/2009
GuoDian	580022	600795	Call	0	427	—	2.660	0.000	05/22/2008	05/14/2010	05/17/2010	05/21/2010
KangMei	580023	600518	Call	0	167	—	1.029	0.432	05/26/2008	05/18/2009	05/19/2009	05/25/2009
BaoGang	580024	600019	Call	0	1600	—	0.970	-0.670	07/04/2008	06/25/2010	06/28/2010	07/02/2010
GeZhou	580025	600068	Call	0	302	—	1.260	0.424	07/11/2008	12/31/2009	01/04/2010	01/08/2010
JiangTong	580026	600362	Call	0	1761	—	1.227	0.654	10/10/2008	09/21/2010	09/27/2010	10/08/2010
ChangHong	580027	600839	Call	0	573	—	1.444	0.198	08/19/2009	08/11/2011	08/12/2011	08/18/2011
NanHang	580989	600029	Put	1	1400	12832	0.440	-0.132	06/21/2007	06/13/2008	06/20/2008	06/20/2008
MaoTai	580990	600519	Put	1	432	768	0.149	-1.141	05/30/2006	05/22/2007	05/29/2007	05/29/2007
HaiEr	580991	600690	Put	1	607	767	0.461	-1.303	05/17/2006	05/09/2007	05/10/2007	05/16/2007
YaGe	580992	600177	Put	1	635	754	0.187	-1.866	05/22/2006	05/14/2007	05/17/2007	05/21/2007
WanHua	580993	600309	Put	1	85	191	1.172	-1.436	04/27/2006	04/19/2007	04/20/2007	04/26/2007
YuanShui	580994	600649	Put	1	280	366	0.812	-0.289	04/19/2006	02/05/2007	02/06/2007	02/12/2007
BaoGang	580995	600010	Put	1	715	834	0.480	-0.878	03/31/2006	03/23/2007	03/26/2007	03/30/2007
HuChang	580996	600009	Put	1	568	593	2.252	-0.647	03/07/2006	02/27/2007	03/06/2007	03/06/2007
ZhaoHang	580997	600036	Put	1	2241	6536	0.436	-1.969	03/02/2006	08/24/2007	08/27/2007	08/31/2007

Table 2: **Summary Statistics for Each Group of Warrants**

This table reports, for each group of warrants, the average number of investors (NoInv, in thousands), the average number of institutions (NoIns), the average moneyness (Money= $\log[S_T/K]$ for calls; Money= $-\log[S_T/K]$ for puts) on the last trading day, the average total trading volume (Volume, in billions), the average turnover value (Value, in billions of CNY), the average turnover value per investor (ValpInv, in millions of CNY), the average gross profit (GroProf, excluding fees, in millions of CNY),and the average net profit (NetProf, including fees, in millions of CNY). The column *N* reports the number of warrants in each group. *t*-statistics for testing whether these sample means are different from zero are also computed. Differences between the out-of-the-money (OTM) and in-the-money (ITM) groups together with *t*-statistics for testing whether these differences are equal to zero are reported as well. Statistical significance at the 10%, 5%, and 1% levels is indicated by *, **, and ***, respectively. The aggregate gross profit from trading OTM (ITM) warrants is -897.3 million CNY (227.1 million CNY). The aggregate net profit from trading OTM (ITM) warrants is -1376.3 million CNY (-86.7 million CNY).

Group	NoInv	NoIns	Money	Volume	Value	ValpInv	GroProf	NetProf	*N*
Overall	24.7***	22.5***	0.015	14.697***	31.191***	0.952***	-13.962	-30.478**	48
OTM	29.9***	23.8***	-0.862***	24.135**	37.387***	0.822***	-39.011**	-59.837***	23
ITM	19.9***	21.4***	0.821***	6.013***	25.490***	1.072***	9.084	-3.467	25
OTM-ITM	10.0*	2.4	-1.683***	18.123*	11.898	-0.250*	-48.095***	-56.370**	—

Table 3: **Distribution of Aggregate Profits, Aggregate Trading Volume, Aggregate Turnover Value, Aggregate Number of Trades, and Average Turnover Value Per Trade for Each Investor**

This table reports percentiles of aggregate profits, aggregate trading volume, aggregate turnover value, aggregate number of trades, and average turnover value per trade for all investors. We first consider the sample with all investors; then we split the sample into institutions and individuals. The sample mean, sample skewness, and total value are also reported.

Investor Type	Percentiles									Mean	Skew.	Total	*N*
	1st	5th	10th	25th	Median	75th	90th	95th	99th				
	Panel A: Gross profit												
All	-1.5e+05	-3.4e+04	-1.5e+04	-3.2e+03	-2.7e+02	1.0e+02	2.0e+03	7.4e+03	7.2e+04	-3.0e+03	6.2e+01	-6.7e+08	223745
Institution	-2.0e+06	-5.6e+05	-2.0e+05	-2.8e+04	-8.7e+02	8.6e+03	1.7e+05	6.3e+05	2.4e+06	7.3e+04	9.1e+00	1.8e+07	246
Individual	-1.4e+05	-3.4e+04	-1.5e+04	-3.2e+03	-2.7e+02	1.0e+02	2.0e+03	7.4e+03	7.1e+04	-3.1e+03	6.3e+01	-6.9e+08	223499
	Panel B: Net profit												
All	-1.8e+05	-4.4e+04	-2.0e+04	-4.6e+03	-5.5e+02	1.0e+00	9.2e+02	4.3e+03	5.2e+04	-6.5e+03	5.2e+01	-1.5e+09	223745
Institution	-2.1e+06	-6.7e+05	-2.4e+05	-5.4e+04	-1.3e+03	5.7e+03	1.4e+05	5.0e+05	2.3e+06	3.9e+04	8.7e+00	9.6e+06	246
Individual	-1.7e+05	-4.3e+04	-2.0e+04	-4.6e+03	-5.5e+02	1.0e+00	9.1e+02	4.2e+03	5.1e+04	-6.6e+03	5.3e+01	-1.5e+09	223499
	Panel C: Trading volume												
All	2.0e+02	6.0e+02	2.0e+03	9.0e+03	5.5e+04	3.4e+05	1.6e+06	4.2e+06	2.6e+07	3.2e+06	9.7e+01	7.1e+11	
Institution	2.0e+02	4.5e+03	2.0e+04	9.0e+04	7.7e+05	5.2e+06	3.0e+07	1.0e+08	2.8e+08	1.7e+07	6.9e+00	4.2e+09	
Individual	2.0e+02	6.0e+02	2.0e+03	9.0e+03	5.5e+04	3.4e+05	1.6e+06	4.2e+06	2.6e+07	3.1e+06	9.7e+01	7.0e+11	
	Panel D: Turnove value												
All	2.8e+02	1.3e+03	3.8e+03	2.1e+04	1.3e+05	7.3e+05	3.4e+06	8.6e+06	5.6e+07	6.7e+06	9.1e+01	1.5e+12	
Institution	7.1e+02	7.2e+03	6.2e+04	3.8e+05	2.9e+06	1.5e+07	8.7e+07	2.4e+08	8.0e+08	4.1e+07	5.9e+00	1.0e+10	
Individual	2.8e+02	1.3e+03	3.8e+03	2.1e+04	1.3e+05	7.3e+05	3.4e+06	8.5e+06	5.5e+07	6.7e+06	9.1e+01	1.5e+12	
	Panel E: Number of trades												
All	2	2	2	5	16	58	172	323	1143	9.5e+01	4.4e+01	2.1e+07	
Institution	1	2	2	5	19	75	231	423	2043	1.1e+02	7.9e+00	2.8e+04	
Individual	2	2	2	5	16	58	172	323	1142	9.5e+01	4.4e+01	2.1e+07	
	Panel F: Averaged value per trade												
All	1.3e+02	4.2e+02	8.4e+02	2.5e+03	6.7e+03	1.8e+04	4.8e+04	8.8e+04	2.9e+05	2.3e+04	1.3e+01	—	
Institution	5.3e+02	2.4e+03	7.9e+03	3.6e+04	1.5e+05	4.0e+05	7.7e+05	1.2e+06	1.9e+06	3.1e+05	2.8e+00	—	
Individual	1.3e+02	4.2e+02	8.4e+02	2.5e+03	6.7e+03	1.8e+04	4.8e+04	8.7e+04	2.8e+05	2.3e+04	1.3e+01	—	

Table 4: **OLS Regressions of Profits and Trading Volume on Value Weighted Ex Ante Skewness and Other Variables**

This table presents results of OLS regressions of investors' aggregate profits and trading volume on value-weighted variables including skewness, leverage, moneyness, delta, vega, gamma, price, and relative value. Leverage is the option elasticity (i.e., the leverage implicit in the option) defined as the percentage change in the option price relative to the percentage change in the underlying. Volatility for one specific warrant on trading day t is defined as $(High_t - Low_t)/Close_{t-1}$, where $High_t$ is day high on day t, Low_t is day low on day t, and $Close_{t-1}$ is the closing price on day $t-1$. Moneyness is defined as $\log(S/K)$ for calls, and as $-\log(S/K)$ for puts. Delta is defined as the absolute value of Black-Scholes delta for options. The relative value ("RelValue") is defined as the Black-Scholes value over the transaction price. Other variables are computed under the Black-Scholes model. t-statistics are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is indicated by *, **, and ***, respectively.

	Panel A: Regressions of gross profits									
Skewness	-2.61***									-1.56***
	(-12.97)									(-2.60)
Leverage		5.35***								1.98
		(7.34)								(0.94)
Volatility			-3.09***							0.14
			(-14.52)							(0.37)
Moneyness				3.95***						7.59***
				(9.89)						(4.13)
Delta					2.91***					-11.88***
					(6.40)					(-4.83)
Vega						0.71				-5.45***
						(0.55)				(-4.14)
Gamma							11.08***			2.45**
							(5.44)			(2.47)
RelValue								2.15***		7.52***
								(4.02)		(3.66)
Price									4.41***	1.47
									(13.52)	(1.44)
Intercept	1.82***	-2.20***	2.07***	-1.49***	-0.97***	0.15	-5.09***	-0.58**	-1.72***	-0.64
	(17.67)	(-5.96)	(18.99)	(-7.35)	(-4.18)	(0.23)	(-4.94)	(-2.14)	(-10.39)	(-1.30)
Adj-R^2	62.80	34.83	67.93	49.44	28.74	0.00	22.39	13.26	64.74	97.34
	Panel B: Regressions of net profits									
Skewness	-2.74***									-2.23***
	(-19.31)									(-3.91)
Leverage		3.22***								-0.44
		(3.25)								(-0.22)
Volatility			-3.40***							0.31
			(-16.95)							(0.77)
Moneyness				3.48***						4.90**
				(6.73)						(2.51)
Delta					2.05***					-9.32***
					(3.67)					(-4.06)
Vega						-5.89***				-5.79***
						(-5.39)				(-5.02)
Gamma							-7.35***			2.51***
							(-2.73)			(2.73)
RelValue								0.62		8.42***
								(1.00)		(4.77)
Price									4.30***	1.45
									(10.96)	(1.39)
Intercept	1.89***	-1.12**	2.22***	-1.25***	-0.53*	3.48***	4.22***	0.19	-1.67***	0.60
	(25.91)	(-2.24)	(21.70)	(-4.77)	(-1.87)	(6.30)	(3.10)	(0.61)	(-8.37)	(1.24)
Adj-R^2	78.98	8.78	74.31	30.89	11.21	22.09	6.13	0.00	54.59	97.81
	Panel C: Regressions of trading volume									
Skewness	2.82***									1.21***
	(71.38)									(4.51)
Leverage		8.11***								-2.04**
		(16.32)								(-2.18)
Volatility			5.98***							1.92***
			(48.38)							(6.44)
Moneyness				0.63						0.42
				(0.34)						(0.43)
Delta					6.02***					-2.61**
					(5.32)					(-2.05)
Vega						5.57***				-1.76**
						(22.03)				(-2.30)
Gamma							6.41***			2.30***
							(23.34)			(5.48)
RelValue								6.65***		4.47***
								(18.39)		(4.16)
Price									-4.86***	-0.22
									(-20.62)	(-0.53)
Intercept	-0.92***	-3.59***	-2.51***	0.19	-2.54***	-2.31***	-2.73***	-2.85***	2.96***	-1.36***
	(-45.21)	(-14.28)	(-40.11)	(0.20)	(-4.43)	(-18.00)	(-19.63)	(-15.58)	(24.72)	(-6.29)
Adj-R^2	98.09	72.82	95.94	0.00	21.60	83.03	84.60	77.29	81.07	99.33

Table 5: **Institutions versus Individuals: Multivariate OLS Regressions of Profits, Trading Volume, and Holding Position on Value Weighted Ex Ante Skewness and Other Variables**
This table presents results of OLS regressions of institutional investors' gross profits, net profits, trading volume and holding position on value weighted variables including skewness, leverage, moneyness, delta, vega, gamma, price, and relative value. Leverage is the option elasticity (i.e., the leverage implicit in the option) defined as the percentage change in the option price relative to the percentage change in the underlying. Volatility for one specific warrant on trading day t is defined as $(High_t - Low_t)/Close_{t-1}$, where $High_t$ is day high on t, Low_t is day low on t, and $Close_{t-1}$ is the closing price on $t-1$. Moneyness is defined as $\log(S/K)$ for calls, and as $-\log(S/K)$ for puts. Delta is defined as the absolute value of Black-Scholes delta for options. For each investor, "Dummy" is defined as a value weighted dummy variable, which is equal to 1 if one specific trading occurs on or after May 30, 2007, and is equal to 0 otherwise. The relative value ("RelValue") is defined as the Black-Scholes value over the transaction price. Other variables are computed under the Black-Scholes model. t-statistics are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is indicated by *, **, and ***, respectively.

	Gross Profits		Net Profits		Trading Volume		Holding Position	
	Insti.	Indiv.	Insti.	Indiv.	Insti.	Indiv.	Insti.	Indiv.
Skewness	0.04	-3.08***	0.01	-4.02***	0.72***	1.64***	0.71*	0.79***
	(0.15)	(-4.64)	(0.05)	(-7.68)	(4.39)	(6.22)	(1.83)	(3.15)
Leverage	-0.89**	-0.95	-0.86**	-0.84	0.57**	-3.01***	-0.33	-1.00***
	(-2.53)	(-0.45)	(-2.27)	(-0.41)	(2.02)	(-3.37)	(-0.78)	(-2.64)
Volatility	0.03	1.10***	0.11	1.14***	0.09	1.33***	0.02	0.54***
	(0.15)	(3.23)	(0.59)	(3.01)	(0.66)	(4.45)	(0.06)	(4.33)
Moneyness	0.11	8.75***	0.28	5.53***	-0.41	0.27	0.80*	0.49*
	(0.19)	(5.04)	(0.50)	(2.87)	(-1.07)	(0.29)	(1.72)	(1.74)
Delta	0.82	-5.62**	0.71	-5.79**	-0.33	-2.75**	0.05	1.64***
	(1.25)	(-2.40)	(1.04)	(-2.44)	(-0.74)	(-2.39)	(0.06)	(2.92)
Vega	0.20	-1.20	0.33	-2.14	-0.36*	-1.58**	-0.15	0.48
	(0.71)	(-0.85)	(1.09)	(-1.62)	(-1.70)	(-2.36)	(-0.47)	(1.50)
Gamma	0.30	1.07	0.18	0.72	0.59***	1.86***	-0.40	0.26
	(1.15)	(1.13)	(0.73)	(0.78)	(3.26)	(4.84)	(-1.33)	(1.25)
RelValue	0.05	2.44	0.04	3.61*	0.10	6.30***	0.89	0.13
	(0.11)	(1.15)	(0.07)	(1.78)	(0.30)	(5.80)	(1.26)	(0.23)
Price	-0.50	-1.90*	-0.50*	-0.63	0.89***	-0.87**	-0.80***	-1.97***
	(-1.58)	(-1.88)	(-1.67)	(-0.60)	(4.21)	(-2.09)	(-2.80)	(-8.41)
Dummy	-0.17	-1.46***	0.00	-1.52***	-0.39***	0.36***	0.79***	-0.02
	(-0.94)	(-2.89)	(0.02)	(-3.58)	(-3.20)	(4.13)	(4.65)	(-0.15)
Intercept	0.51*	0.94	0.35	2.50***	-0.24	-1.28***	-0.29	-0.18
	(1.75)	(1.24)	(1.06)	(4.00)	(-1.33)	(-6.47)	(-0.81)	(-0.94)
Adj-R^2	1.12	97.74	0.00	98.05	47.27	99.45	43.72	94.69

Table 6: **Trading Characteristics by Ex Ante Skewness**
We group warrants by day end ex ante skewness into ten groups, and report the average trading volume (in millions), turnover value (in millions of CNY), day end holding position (in millions), turnover ratio (TRatio, in percent), daily profits (DailyP, in thousands of CNY), daily day trade profits (DayTrP, in thousands of CNY), daily holding profits (HoldingP, in thousands of CNY) and transaction fees (Fares, in thousands of CNY). This table reports sample means within each skewness decile. To save space, we combine the second to the ninth deciles into a single group. The differences between extreme deciles as well as the corresponding *t*-statistics for testing the null of no difference are computed. Panel A reports results for all investors. Panels B and C report results for individuals and institutions, respectively. *t*-statistics are reported in parentheses. Statistical significance at the 10%, 5%, and 1% levels is indicated by *, **, and ***, respectively.

	Trading Characteristics								
Skewness Deciles	N	Volume	Turnover	Holding	TRatio	DailyP	DayTrP	HoldingP	Fares
	Panel A: All Investors								
Low	1063	15.27	86.37	3.23	5.87	-9.79	-49.56	39.77	49.53
$2 \sim 9$	8507	67.50	149.75	15.00	10.96	-116.68	-77.12	-39.55	72.98
High	1063	108.15	123.60	17.06	15.11	-468.38	-130.15	-338.23	112.13
High-Low	—	92.88***	37.22***	13.82***	9.23***	-458.59**	-80.59**	-378.00**	62.60***
(t-stat)	—	(10.69)	(4.91)	(11.68)	(13.00)	(-2.32)	(-2.08)	(-1.98)	(7.70)
	Panel B: Individual Investors								
Low	1063	15.08	85.30	3.14	5.82	-9.26	-45.87	36.62	48.82
$2 \sim 9$	8507	67.14	148.84	14.78	10.91	-116.16	-75.90	-40.26	72.21
High	1063	107.32	122.40	16.89	15.03	-482.18	-140.46	-341.72	111.24
High-Low	—	92.24***	37.10***	13.75***	9.20***	-472.92**	-94.58**	-378.34**	62.42***
(t-stat)	—	(10.69)	(4.97)	(11.71)	(13.00)	(-2.50)	(-2.49)	(-2.05)	(7.75)
	Panel C: Institutional Investors								
Low	1063	0.19	1.08	0.09	0.05	-0.54	-3.69	3.15	0.72
$2 \sim 9$	8507	0.36	0.91	0.22	0.05	-0.51	-1.22	0.71	0.77
High	1063	0.83	1.20	0.17	0.08	13.80	10.30	3.50	0.89
High-Low	—	0.64***	0.13	0.08***	0.03**	14.34	13.99**	0.35	0.18
(t-stat)	—	(5.12)	(0.59)	(2.94)	(2.35)	(1.00)	(2.57)	(0.03)	(1.25)

Table 7: **Profit Splitting for a Specific Warrant.**
Day 1 is the first trading day, day k is the last trading day, and day $k+1$ represents the day of exercise. c_i denotes the sum of signed cash flows on day i, n_i is the net position change on day i, h_i is the holding position at the end of day i, and p_i is the closing price on day i. p_{k+1} represent the exercise profits (if any). Here $h_0 = 0$, $c_{k+1} = n_{k+1} = 0$, and $n_i = h_i - h_{i-1}$.

	Day 1	Day 2	$\cdots$	Day k	Day $k+1$
Trade	$c_1 + n_1 p_1$	$c_2 + n_2 p_2$	$\cdots$	$c_k + n_k p_k$	$c_{k+1} = n_{k+1} = 0$
Holding	$h_0(p_1 - p_0)$	$h_1(p_2 - p_1)$	$\cdots$	$h_{k-1}(p_k - p_{k-1})$	$h_k(p_{k+1} - p_k)$
Daily	On each day, Daily Profit = Day Trade Profit + Holding Profit				

Table 8: **Various Characteristics for Different Groups of Investors**

We group investors by their aggregate net profits, and report the sample averages of various characteristics including value per trade (ValpTr, in thousands of CNY), net profits (NetProf, in thousands of CNY), number of trades (NoTrade), ex ante skewness (Skew), and holding ratio (HoRatio, in percent). In the last two rows of each panel, we report the differences between the top 0.1% and the bottom 0.1%, as well as the corresponding t-statistics for testing the null of no difference. In the second part (right hand side of the table), we also report some aggregated statistics including turnover value (Turn., in percent w.r.t. total turnover value), net profits (NetP, in percent w.r.t. total net profits), holding profit ratio (HoPRatio, in percent w.r.t. net profits of the same group), and transaction fees ratio (FareRatio, in percent w.r.t. net profits of the same group). Profits per turnover value (PpTurn, in percent) in each group are also reported. The column NoInvU (NoInsU) reports the number of investors (institutions) that ever held warrants and their underlying assets simultaneously. There are 2539 put warrant investors (3 institutions) that ever held both the underlying and corresponding warrants. The average holding period for the underlying asset is 31.4 (14.0) trading days for individuals (institutions). Statistical significance at the 10%, 5%, and 1% levels is indicated by *, **, and ***, respectively.

Investor	Averaged Group Characteristics					Aggregated Group Characteristics						
Group	ValpTr	NetProf	NoTrade	Skew	HoRatio	Turn.	NetP	HoPRatio	FareRatio	PpTurn	NoInvU	NoInsU
	Panel A: Sort by net profits											
Top 0.1%	442.67	2602.27	6648.83	55.81	4.08	44.2	-40.0	39.5	18.2	0.09	2	0
0.1%∼1%	113.05	155.55	864.97	49.80	22.18	13.1	-21.4	92.8	26.5	0.16	25	1
1%∼10%	39.57	7.83	91.26	51.81	51.41	4.9	-10.8	151.6	43.8	0.22	228	1
10%∼30%	10.65	0.17	12.47	52.75	56.89	0.4	-0.5	176.5	115.3	0.13	491	0
30%∼70%	8.73	-0.86	27.52	54.82	51.03	1.4	5.2	1.0	-44.0	-0.36	952	0
70%∼90%	15.89	-8.35	115.24	54.71	48.55	5.5	25.5	26.5	-28.3	-0.46	547	0
90%∼99%	37.52	-52.32	308.09	54.94	42.33	15.5	72.0	35.8	-22.2	-0.45	259	1
99%∼99.9%	109.43	-321.92	747.68	57.41	33.99	11.0	44.3	41.6	-17.0	-0.39	33	0
Bottom 0.1%	268.37	-1674.89	973.21	57.22	49.84	3.9	25.6	46.7	-11.3	-0.64	2	0
Difference	174.30*	4277.16***	5675.62***	-1.41***	-45.75***							
(t-stat)	(1.90)	(15.64)	(7.61)	(-2.85)	(-2.67)	—	—	—	—	—	—	—
	Panel B: Sort by value per trade											
Top 0.1%	1167.37	674.91	797.07	56.84	8.55	14.0	-10.4	42.8	27.0	0.07	6	1
0.1%∼1%	492.90	6.66	513.17	55.89	11.56	34.0	-0.9	367.8	1125.9	0.00	25	1
1%∼10%	114.36	-29.95	239.04	52.56	23.79	36.8	41.2	-1.4	-49.3	-0.11	232	0
10%∼30%	27.30	-12.84	136.59	55.37	50.17	11.1	39.3	19.5	-32.6	-0.34	503	1
30%∼70%	8.01	-4.37	80.32	57.83	84.20	3.8	26.7	32.6	-26.8	-0.68	1012	0
70%∼90%	2.15	-1.22	37.27	62.76	154.82	0.2	3.7	50.4	-20.1	-1.52	466	0
90%∼99%	0.55	-0.25	8.89	69.46	402.26	0.0	0.3	61.8	-17.6	-5.03	274	0
99%∼99.9%	0.09	-0.05	2.89	81.43	680.53	0.0	0.0	47.8	-28.4	-20.37	19	0
Bottom 0.1%	0.02	-0.02	1.89	93.92	394.12	0.0	0.0	36.5	-41.1	-78.81	2	0
Difference	1167.36***	674.94**	795.18***	-37.07***	-385.57***							
(t-stat)	(44.07)	(2.46)	(3.93)	(-26.36)	(-4.01)	—	—	—	—	—	—	—

Table 9: **Trading Volume and Holding Position During the Last Ten Trading Days of OTM Expired Warrants**
The table reports the average (across warrants) proportion (in percent) in daily trading volume and day-end holding position by different groups of investors during the last ten trading days for all OTM warrants. Column (1) reports results for the last trading day, Column (2) reports results for the penultimate trading day, and so on and so forth. The Column (1)-(10) reports the differences between the column (1) and the column (10); the column (1)-(5) is defined analogously. The last row reports the sample size for each column. Statistical significance at the 10%, 5%, and 1% levels is indicated by *, **, and ***, respectively.

	Number of Trading Days to the Last Trading Day										Differences	
Groups	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)	(1)-(10)	(1)-(5)
	Panel A: Trading Volume											
Individuals	99.75***	99.71***	98.89***	99.94***	99.49***	99.93***	99.93***	99.95***	99.67***	98.92***	-0.83	-1.00
Institutions	0.25*	0.29	1.11	0.06**	0.51	0.07**	0.07***	0.05	0.33	1.08	0.83	1.00
Top 0.1%	28.36***	30.94***	28.46***	29.36***	29.61***	29.37***	29.69***	25.60***	23.45***	19.18***	-9.18**	-10.19**
0.1%∼10%	15.97***	15.24***	14.67***	17.23***	16.39***	14.75***	13.13***	13.24***	14.49***	11.60***	-4.37	-3.15
10%∼90%	13.65***	11.82***	13.82***	13.02***	12.92***	12.31***	13.64***	14.80***	13.51***	17.16***	3.51*	4.85**
Bottom 10%	42.02***	42.01***	43.04***	40.39***	41.08***	43.57***	43.54***	46.36***	48.56***	52.06***	10.04***	8.49**
	Panel B: Holding Position											
Individuals	99.72***	99.88***	99.81***	99.77***	99.79***	99.79***	99.53***	99.98***	98.91***	99.75***	0.04	-0.04
Institutions	0.28*	0.12*	0.19	0.23*	0.21	0.21	0.47	0.02	1.09	0.25*	-0.04	0.04
Top 0.1%	6.76***	4.67***	4.28**	2.88***	4.19***	4.79***	3.85***	3.82*	2.92**	0.29	-6.46***	-4.50**
0.1%∼10%	12.53***	12.81***	11.89***	13.71***	9.98***	10.55***	8.12***	10.88***	10.35***	4.50***	-8.03***	-6.05***
10%∼90%	18.60***	19.15***	19.28***	18.68***	17.52***	17.82***	17.50***	17.26***	17.13***	31.55***	12.96***	13.74***
Bottom 10%	62.11***	63.36***	64.55***	64.73***	68.31***	66.84***	70.53***	68.04***	69.60***	63.66***	1.54	-3.18
N	19	17	18	19	19	19	18	18	18	18	—	—

Table 10: **Profits During the Last Ten Trading Days of OTM Expired Warrants**
The table reports the average (across warrants) total daily profits during the last ten trading days for all OTM warrants. We report results for day trade profit, holding profit, and daily profit measured in million CNY. The column (1) reports results for the last trading day, the column (2) reports results for the penultimate trading day, and so on and so forth. The last column reports aggregated results for the last five trading days. The last row reports the sample size for each column. Statistical significance at the 10%, 5%, and 1% levels is indicated by *, **, and ***, respectively.

	Number of Trading Days to the Last Trading Day										
Groups	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)	(5)∼(1)
	Panel A: Day Trade Profit										
Individuals	-0.217*	-0.212	-1.556	0.200	-0.246	-0.412	-0.239	0.064	-0.321***	-0.031	-0.910**
Institutions	-0.002	0.024	0.004	0.019	0.018	-0.004	-0.001	0.004*	-0.010	-0.008	-0.018
Top 0.1%	-0.005	0.465	-0.404	0.687	0.193	-0.143	0.171	0.215	-0.001	0.122	0.337
0.1%∼10%	0.003	0.132	-0.092	0.188	0.122**	0.062	-0.000	0.096*	0.040	0.080	0.266***
10%∼90%	-0.054***	-0.124**	-0.049***	-0.188	-0.105*	-0.096***	-0.091***	-0.180*	-0.072***	-0.147***	-0.560***
Bottom 10%	-0.162	-0.661*	-1.007	-0.468	-0.438	-0.239*	-0.320***	-0.062	-0.298***	-0.094	-0.972***
	Panel B: Holding Profit										
Individuals	0.656	-0.382	2.714	0.969	-2.034	-2.387*	-0.055	-2.331**	-2.458***	-2.976***	-9.796***
Institutions	0.032	-0.006	-0.000	0.006	-0.018	-0.001	-0.000	-0.004	-0.000	-0.022	-0.027
Top 0.1%	0.108	-0.063	0.984	0.445	-0.398	-0.197	0.146	-0.160	-0.136	-0.108*	-0.441*
0.1%∼10%	0.259	-0.071	0.545	0.268	-0.184	-0.190**	0.026	-0.151*	-0.198***	-0.250***	-0.733***
10%∼90%	0.063	-0.029	0.048	0.003	-0.194	-0.270**	-0.076	-0.260***	-0.373***	-0.488***	-1.404***
Bottom 10%	0.258	-0.225	1.137	0.259	-1.276	-1.731*	-0.151	-1.765**	-1.751***	-2.152***	-7.244***
	Panel C: Daily Profit										
Individuals	0.439	-0.593	1.158	1.169	-2.280	-2.799*	-0.294	-2.266**	-2.779***	-3.007***	-10.706***
Institutions	0.030	0.017	0.004	0.025	-0.000	-0.005	-0.002	0.000	-0.011	-0.030	-0.045
Top 0.1%	0.103	0.402	0.580	1.131	-0.204	-0.340	0.317	0.055	-0.137*	0.015	-0.104
0.1%∼10%	0.262	0.061	0.453	0.457	-0.062	-0.128	0.026	-0.055	-0.159*	-0.170**	-0.467**
10%∼90%	0.009	-0.153*	-0.001	-0.185***	-0.299	-0.366***	-0.167	-0.439**	-0.445***	-0.635***	-1.964***
Bottom 10%	0.096	-0.886	0.130	-0.209	-1.714	-1.970*	-0.472	-1.827**	-2.049***	-2.246***	-8.216***
N	19	17	18	19	19	19	18	18	18	18	19

Table 11: **Warrants with Guaranteed Zero Payoff on the Last Trading Day**

The table reports the trading summaries for 17 warrants that have guaranteed zero payoff on at least one trading day of their lifespan. Panel A reports statistics for the first day that the warrant has guaranteed zero payoff (i.e., the maximum possible payoff is zero) at market close, and Panel B reports results for the last trading day. We report day high, day low, closing price, volume weighted mean price, and trading volume. On the last trading day of each warrant, we also report the trading volume share (in percent) for institutions (R_{Ins}), for the top 0.1% of investors ($R_{0.1}$), for group $(0.1\%,\ 10\%]$ ($R_{0.1,10}$), for group $(10\%,\ 90\%]$ ($R_{10,90}$), and for the bottom 10% of investors ($R_{>90}$). The maximum possible payoff at market close is computed according to the price limit rule in the stock market: for call warrants we assume the underlying stock increases by 10% per trading day, while for put warrants we assume the underlying stock decreases by 10% per trading day.

		Panel A: The First Day with Zero Payoff						Panel B: The Last Trading Day									
Code	Type	*Date*	*High*	*Low*	*Close*	*Mean*	*Vol.*	*Date*	*High*	*Low*	*Close*	*Mean*	*Vol.*	R_{Ins}	$R_{0.1}$	$R_{0.1,10}$	$R_{10,90}$	$R_{>90}$
580014	Call	10/19/2009	1.674	1.171	1.199	1.389	N/A	10/22/2009	0.545	0.011	0.016	0.408	N/A	N/A	N/A	N/A	N/A	N/A
580018	Call	08/18/2009	—	—	—	—	—	08/18/2009	2.100	0.831	0.957	1.438	0.085×10^9	0.235	33.647	12.522	12.845	40.986
580019	Call	02/24/2010	—	—	—	—	—	02/24/2010	0.018	0.001	0.001	0.007	N/A	N/A	N/A	N/A	N/A	N/A
580020	Call	02/25/2009	1.497	1.006	1.023	1.384	0.174×10^9	02/27/2009	0.550	0.024	0.024	0.313	0.534×10^9	0.005	14.395	7.748	13.468	64.389
580024	Call	06/24/2010	0.024	0.010	0.011	0.018	N/A	06/25/2010	0.016	0.001	0.001	0.009	N/A	N/A	N/A	N/A	N/A	N/A
038001	Put	04/17/2007	0.780	0.681	0.716	0.725	0.027×10^9	04/24/2007	0.320	0.008	0.010	0.137	0.126×10^9	1.090	10.340	5.303	27.119	57.237
038003	Put	02/18/2008	0.210	0.178	0.190	0.197	0.089×10^9	02/22/2008	0.150	0.010	0.010	0.078	0.527×10^9	0.000	25.572	5.556	16.079	52.792
038004	Put	03/10/2008	0.542	0.443	0.447	0.491	0.052×10^9	03/26/2008	0.080	0.004	0.004	0.049	0.511×10^9	0.000	34.247	7.220	19.931	38.602
038006	Put	11/07/2007	0.546	0.430	0.438	0.499	0.125×10^9	11/16/2007	0.107	0.010	0.010	0.066	0.919×10^9	0.000	3.905	52.319	7.720	36.057
038008	Put	06/15/2007	6.990	4.080	5.400	5.542	0.067×10^9	06/22/2007	1.000	0.100	0.107	0.598	0.147×10^9	0.000	23.894	13.593	12.868	49.645
580990	Put	05/15/2007	0.335	0.257	0.299	0.300	0.295×10^9	05/22/2007	0.041	0.002	0.003	0.017	0.308×10^9	12.969	0.936	5.794	21.828	71.442
580991	Put	04/24/2007	0.485	0.417	0.480	0.449	0.071×10^9	05/09/2007	0.110	0.001	0.001	0.042	0.350×10^9	0.000	7.144	13.182	24.509	55.165
580992	Put	04/23/2007	0.482	0.442	0.451	0.457	0.032×10^9	05/14/2007	0.059	0.002	0.002	0.022	0.386×10^9	0.000	3.760	7.913	22.715	65.612
580993	Put	04/10/2007	0.732	0.595	0.598	0.675	0.028×10^9	04/19/2007	0.441	0.067	0.087	0.178	0.165×10^9	0.295	22.888	4.438	12.080	60.593
580995	Put	03/21/2007	0.501	0.375	0.491	0.426	0.216×10^9	03/23/2007	0.270	0.005	0.006	0.104	0.421×10^9	0.004	15.543	9.485	25.387	49.585
580996	Put	02/16/2007	0.527	0.441	0.500	0.478	0.121×10^9	02/27/2007	0.442	0.012	0.015	0.188	0.227×10^9	0.000	10.026	6.382	16.654	66.938
580997	Put	08/08/2007	0.345	0.298	0.303	0.316	0.690×10^9	08/24/2007	0.176	0.001	0.002	0.057	2.954×10^9	0.132	33.261	8.759	12.716	45.264

Table 12: **Warrants' Theoretical Prices and Their Daily Price Limits**
The table reports the number of trading days (during the last 20 trading days of each warrant) on which warrants' lower price limit for trading is higher than their day-end theoretical prices. Three proxies for theoretical prices are used here. The column N_{BS1} uses the Black-Scholes prices with volatility parameter set as the 60-day trailing historical volatility σ_{60} of underlying asset, the column N_{BS2} uses the Black-Scholes prices with $2 \times \sigma_{60}$ as volatility parameter, and the column N_{Max} uses the warrant's maximum possible payoff under the price limit rule for underlying asset. We use the Shanghai Interbank Offered Rate (SHIBOR) as the interest rate proxy when computing Black-Scholes value.

Code	Type	N_{BS1}	N_{BS2}	N_{Max}
031004	Call	6	5	0
031005	Call	13	10	0
031006	Call	2	0	0
580010	Call	5	4	0
580012	Call	7	5	0
580013	Call	14	14	0
580014	Call	15	15	4
580015	Call	11	10	0
580017	Call	8	4	0
580018	Call	16	16	2
580019	Call	1	1	0
580020	Call	16	16	4
580021	Call	14	13	0
580023	Call	11	2	0
580025	Call	1	1	0
038008	Put	1	1	0
580989	Put	2	2	0

Online Appendix to

"Winners, Losers, and Regulators in a Nascent Derivatives Market: Evidence from Chinese Brokerage Data"

Xindan Li[1], Avanidhar Subrahmanyam[2], and Xuewei Yang[3]

May 7, 2018

In this appendix we provide some ancillary empirical results.

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Table OA.1: **Warrants with Guaranteed Zero Payoff before Market Opening of the Last Trading Day**
The table reports the trading summaries for 15 warrants that have guaranteed zero payoff on at least one trading day of their lifespan. Panel A reports statistics for the first day that the warrant has guaranteed zero payoff (i.e., the maximum possible payoff is zero) before market opening, and Panel B reports results for the last trading day. We report day high, day low, closing price, volume weighted mean price, and trading volume. On the last trading day of each warrant, we also report the trading volume share (in percent) for institutions (R_{Ins}), for the top 0.1% of investors ($R_{0.1}$), for group $(0.1\%,\ 10\%]$ ($R_{0.1,10}$), for group $(10\%,\ 90\%]$ ($R_{10,90}$), and for the bottom 10% of investors ($R_{>90}$). The maximum possible payoff before market opening is computed according to the price limit rule in the stock market: for call warrants we assume the underlying stock increases by 10% per trading day, while for put warrants we assume the underlying stock decreases by 10% per trading day.

		Panel A: The First Day with Zero Payoff						Panel B: The Last Trading Day									
Code	Type	*Date*	*High*	*Low*	*Close*	*Mean*	*Vol.*	*Date*	*High*	*Low*	*Close*	*Mean*	*Vol.*	R_{Ins}	$R_{0.1}$	$R_{0.1,10}$	$R_{10,90}$	$R_{>90}$
580014	Call	10/20/2009	1.222	0.830	0.842	1.035	N/A	10/22/2009	0.545	0.011	0.016	0.408	N/A	N/A	N/A	N/A	N/A	N/A
580020	Call	02/26/2009	1.099	0.511	0.511	0.888	0.150×10^9	02/27/2009	0.550	0.024	0.024	0.313	0.534×10^9	0.005	14.395	7.748	13.468	64.389
580024	Call	06/25/2010	—	—	—	—	—	06/25/2010	0.016	0.001	0.001	0.009	N/A	N/A	N/A	N/A	N/A	N/A
038001	Put	04/18/2007	0.770	0.681	0.730	0.722	0.019×10^9	04/24/2007	0.320	0.008	0.010	0.137	0.126×10^9	1.090	10.340	5.303	27.119	57.237
038003	Put	02/19/2008	0.199	0.180	0.185	0.190	0.050×10^9	02/22/2008	0.150	0.010	0.010	0.078	0.527×10^9	0.000	25.572	5.556	16.079	52.792
038004	Put	03/11/2008	0.491	0.393	0.400	0.454	0.078×10^9	03/26/2008	0.080	0.004	0.004	0.049	0.511×10^9	0.000	34.247	7.220	19.931	38.602
038006	Put	11/08/2007	0.458	0.366	0.371	0.414	0.130×10^9	11/16/2007	0.107	0.010	0.010	0.066	0.919×10^9	0.000	3.905	52.319	7.720	36.057
038008	Put	06/18/2007	6.810	3.150	3.454	5.419	0.056×10^9	06/22/2007	1.000	0.100	0.107	0.598	0.147×10^9	0.000	23.894	13.593	12.868	49.645
580990	Put	05/16/2007	0.324	0.184	0.193	0.244	0.225×10^9	05/22/2007	0.041	0.002	0.003	0.017	0.308×10^9	12.969	0.936	5.794	21.828	71.442
580991	Put	04/25/2007	0.511	0.372	0.379	0.444	0.114×10^9	05/09/2007	0.110	0.001	0.001	0.042	0.350×10^9	0.000	7.144	13.182	24.509	55.165
580992	Put	04/24/2007	0.494	0.451	0.491	0.470	0.041×10^9	05/14/2007	0.059	0.002	0.002	0.022	0.386×10^9	0.000	3.760	7.913	22.715	65.612
580993	Put	04/11/2007	0.646	0.571	0.628	0.612	0.033×10^9	04/19/2007	0.441	0.067	0.087	0.178	0.165×10^9	0.295	22.888	4.438	12.080	60.593
580995	Put	03/22/2007	0.505	0.270	0.288	0.387	0.266×10^9	03/23/2007	0.270	0.005	0.006	0.104	0.421×10^9	0.004	15.543	9.485	25.387	49.585
580996	Put	02/26/2007	0.650	0.418	0.442	0.504	0.138×10^9	02/27/2007	0.442	0.012	0.015	0.188	0.227×10^9	0.000	10.026	6.382	16.654	66.938
580997	Put	08/09/2007	0.313	0.231	0.235	0.270	0.662×10^9	08/24/2007	0.176	0.001	0.002	0.057	2.954×10^9	0.132	33.261	8.759	12.716	45.264

Table OA.2: **Warrants' Theoretical Prices on Previous Trading Day and Their Daily Price Limits**
The table reports the number of trading days (during the last 20 trading days of each warrant) on which warrants' lower price limit for trading is higher than their theoretical prices at the end of the previous trading day. Three proxies for theoretical prices are used here. The column N_{BS1} uses the Black-Scholes prices with volatility parameter set as the 60-day trailing historical volatility σ_{60} of underlying asset, the column N_{BS2} uses the Black-Scholes prices with $2 \times \sigma_{60}$ as volatility parameter, and the column N_{Max} uses the warrant's maximum possible payoff under the price limit rule for underlying asset. We use the Shanghai Interbank Offered Rate (SHIBOR) as the interest rate proxy when computing Black-Scholes value.

Code	Type	N_{BS1}	N_{BS2}	N_{Max}
031004	Call	6	2	0
031005	Call	13	10	0
580010	Call	5	4	0
580012	Call	8	7	0
580013	Call	14	13	0
580014	Call	15	15	3
580015	Call	11	10	0
580017	Call	7	4	0
580018	Call	16	16	0
580019	Call	1	1	0
580020	Call	16	16	3
580021	Call	14	14	0
580023	Call	12	1	0
038008	Put	1	1	0
580989	Put	2	1	0

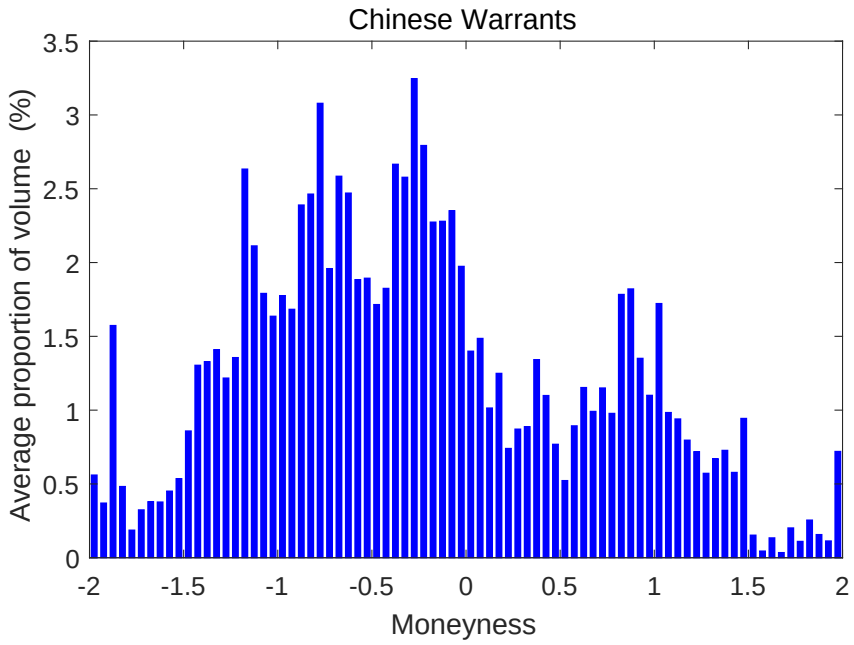

Figure OA.1: Average (across warrants) proportion of trading volume in each bin of moneyness. We first compute the proportion of trading volume in each bin of moneyness for each underlying stock. Then for each moneyness bin, we report the sample average across all 41 underlying stocks.

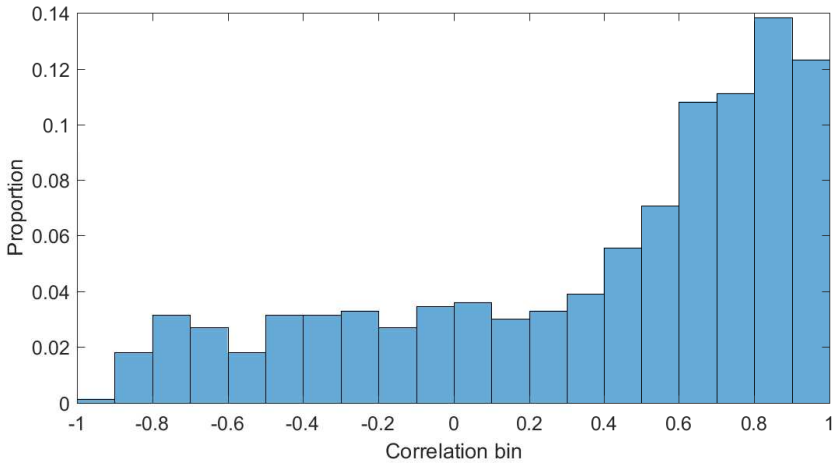

Figure OA.2: Pairwise correlations among time series of closing prices for all of 48 warrants. This figure shows proportions of pairwise correlation coefficients in each bin. The bin size is 0.1.

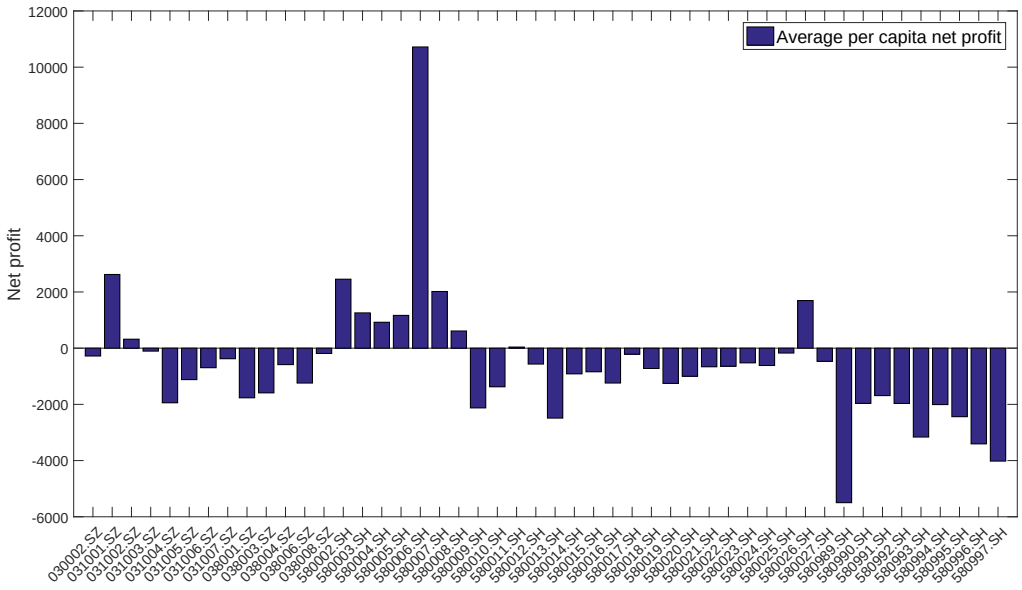

Figure OA.3: Average per capita net profit for each warrant.

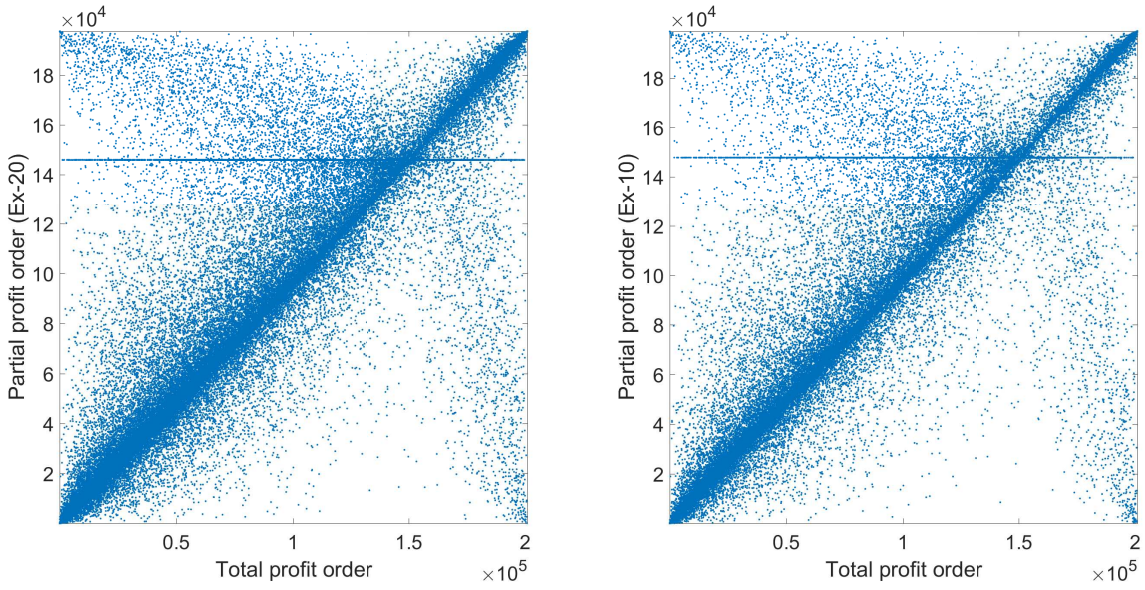

Figure OA.4: Scatter plot of profits for all warrant investors by total and partial profits. The partial profits in the left (resp. right) panel are obtained by excluding the profits of the 20 (resp. 10) days before the last trading day of OTM expired warrants. The correlation between profitability orders of total profits and partial profits is 0.945 (resp. 0.962); the regression coefficient of profitability order of partial profits on that of total profits is 0.975 (resp. 0.984).

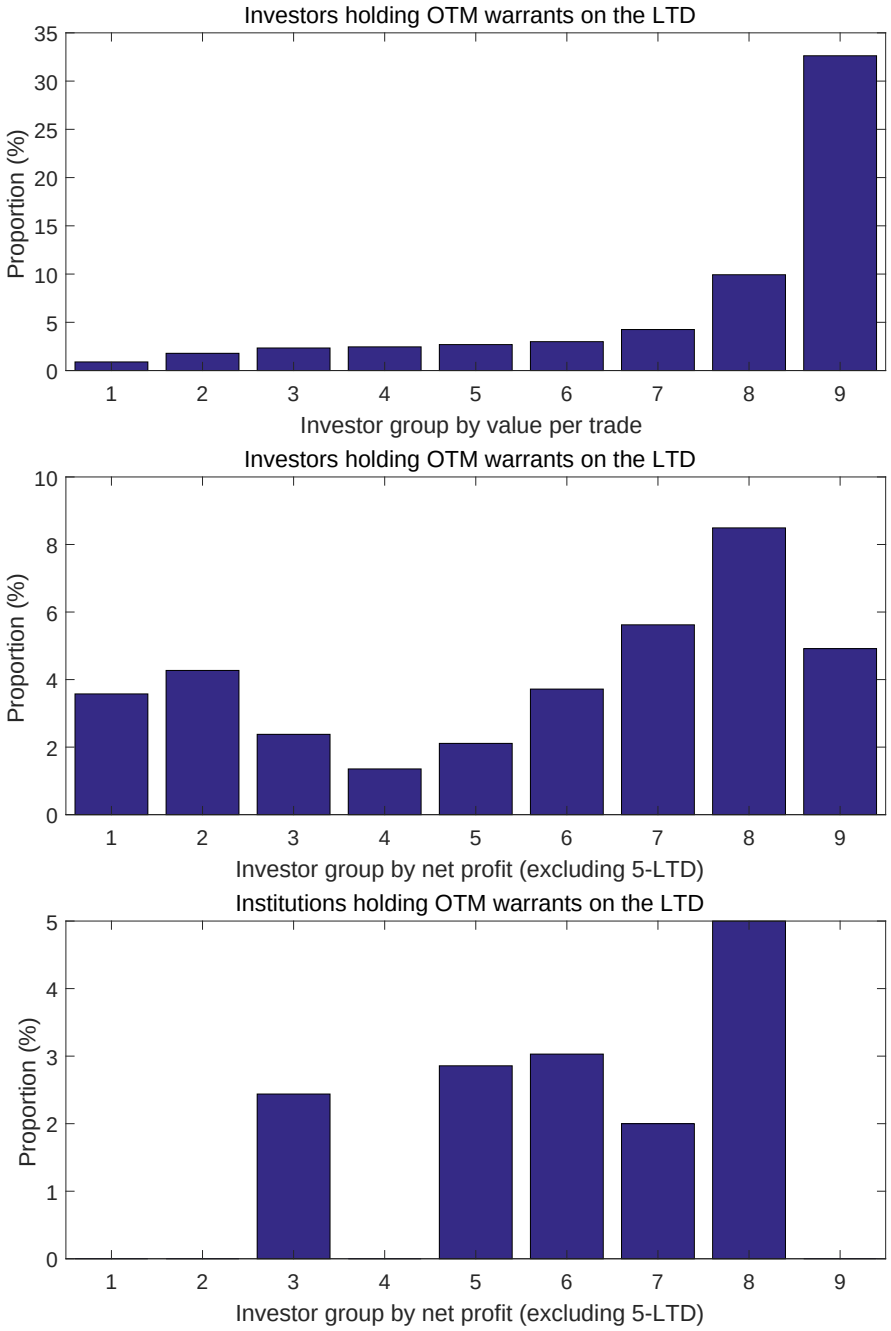

Figure OA.5: Proportion of investors that hold OTM warrants at the end of the last trading day. This figure shows the proportion of investors that hold deep OTM expired warrants (moneyness on the last trading day lower than -0.2) at the end of the last trading day. Here we define moneyness as $\log(S_t/K)$ for calls, and as $-\log(S_t/K)$ for puts, where K is strike price and S_t is underlying price. In the top panel, we sort all investors by their average value per trade, then we divide them into nine groups, which contain investors belonging to the top 0.1% (group 1), 0.1% $\sim$1%, 1%$\sim$10%, , 10%$\sim$30%, 30%$\sim$70%, 70%$\sim$90%, 90%$\sim$99%, 99%$\sim$99.9%, and the bottom 0.1% (group 9), respectively. The middle panel shows the analogue of the top panel while sort all investors by their total net profits (excluding profits/losses accrued in the last 5 trading days of OTM expired warrants). The bottom panel shows the analogue of the middle panel for institutional investors.

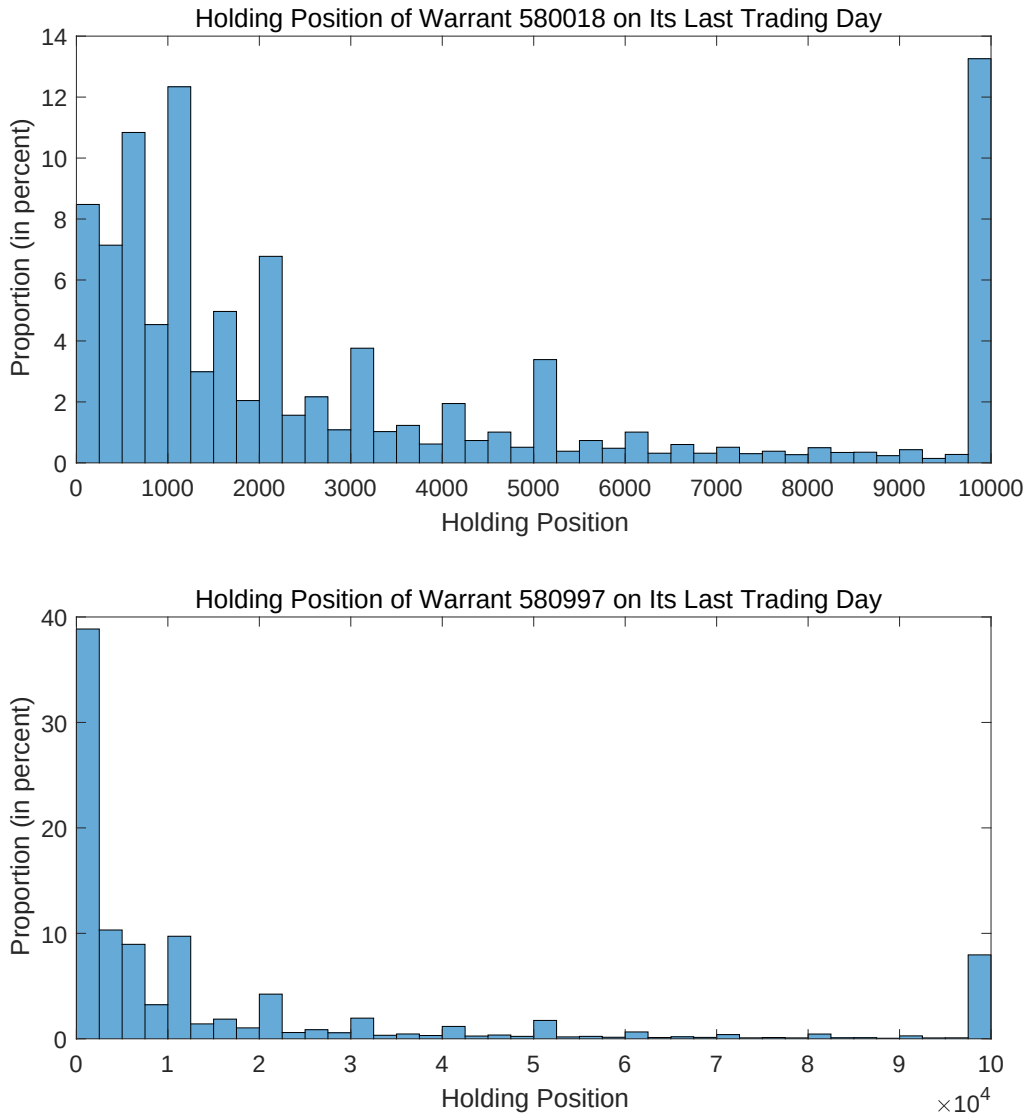

Figure OA.6: Holding Position on the Last Trading Day of Warrant 580018 and Warrant 580997. This figure reports the proportion (in percent) of investors with holding position (in shares) within each bin. The bin size for warrant 580018 (580997) is 250 (2500). In each plot, the number for the last bin includes all investors with position higher than the right most x-tick of the plot. The closing price for warrant 580018 (580997) on its last trading day is 0.957 (0.002) yuan. For more than 99% (60%) of investors that hold warrant 580018 (580997) after market close on the last trading day, their day-end position values are higher than the minimum commission fee of 5 yuan.

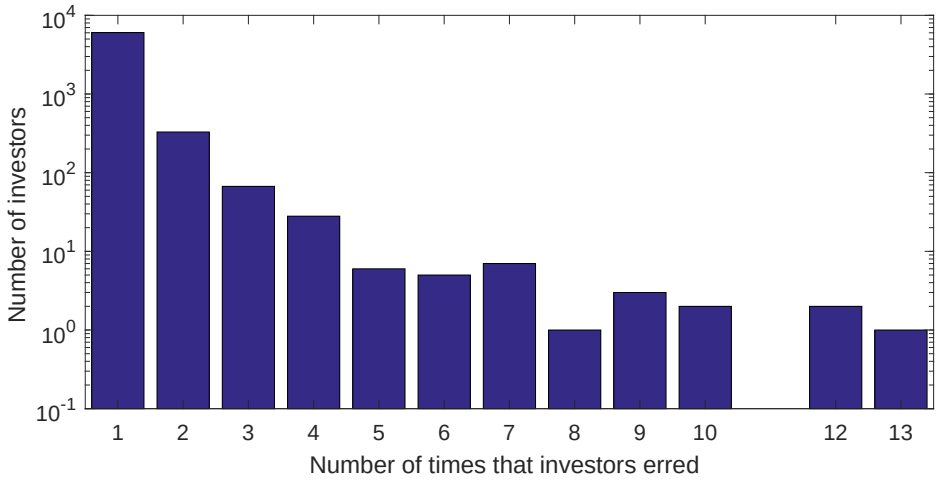

Figure OA.7: Number of times that investors erred. This figure shows the number of investors in each bin of number of times that investors erred, i.e., held one specific deep OTM expired warrant (moneyness on the last trading day lower than -0.2) till the end of its last trading day. Here we define moneyness as $\log(S_t/K)$ for calls, and as $-\log(S_t/K)$ for puts, where K is strike price and S_t is underlying price. The bin size is one. To show the pattern more clearly, we use log-scale for y-axis.

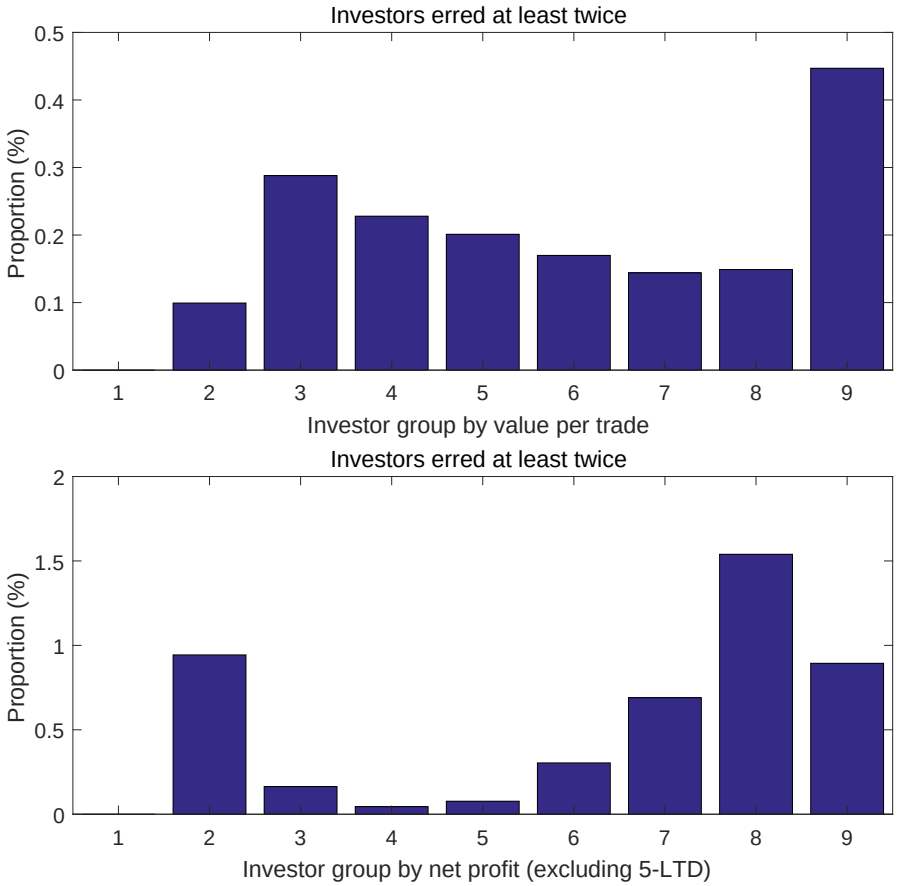

Figure OA.8: Proportion of investors that hold at least two different OTM warrants at the end of their respective last trading days. This figure shows, for each group of investors, the proportion of investors that erred, i.e., held one specific deep OTM expired warrant (moneyness on the last trading day lower than -0.2) at the end of its last trading day, at least twice. Here we define moneyness as $\log(S_t/K)$ for calls, and as $-\log(S_t/K)$ for puts, where K is strike price and S_t is underlying price. In the top panel, we sort all investors by their average value per trade, then we divide them into nine groups, which contain investors belonging to the top 0.1% (group 1), 0.1% $\sim$1%, 1%$\sim$10%, , 10%$\sim$30%, 30%$\sim$70%, 70%$\sim$90%, 90%$\sim$99%, 99%$\sim$99.9%, and the bottom 0.1% (group 9), respectively. The middle panel shows the analogue of the top panel while sort all investors by their total net profits (excluding profits/losses accrued in the last 5 trading days of OTM expired warrants). The number of institutional investors that erred at least twice is zero.

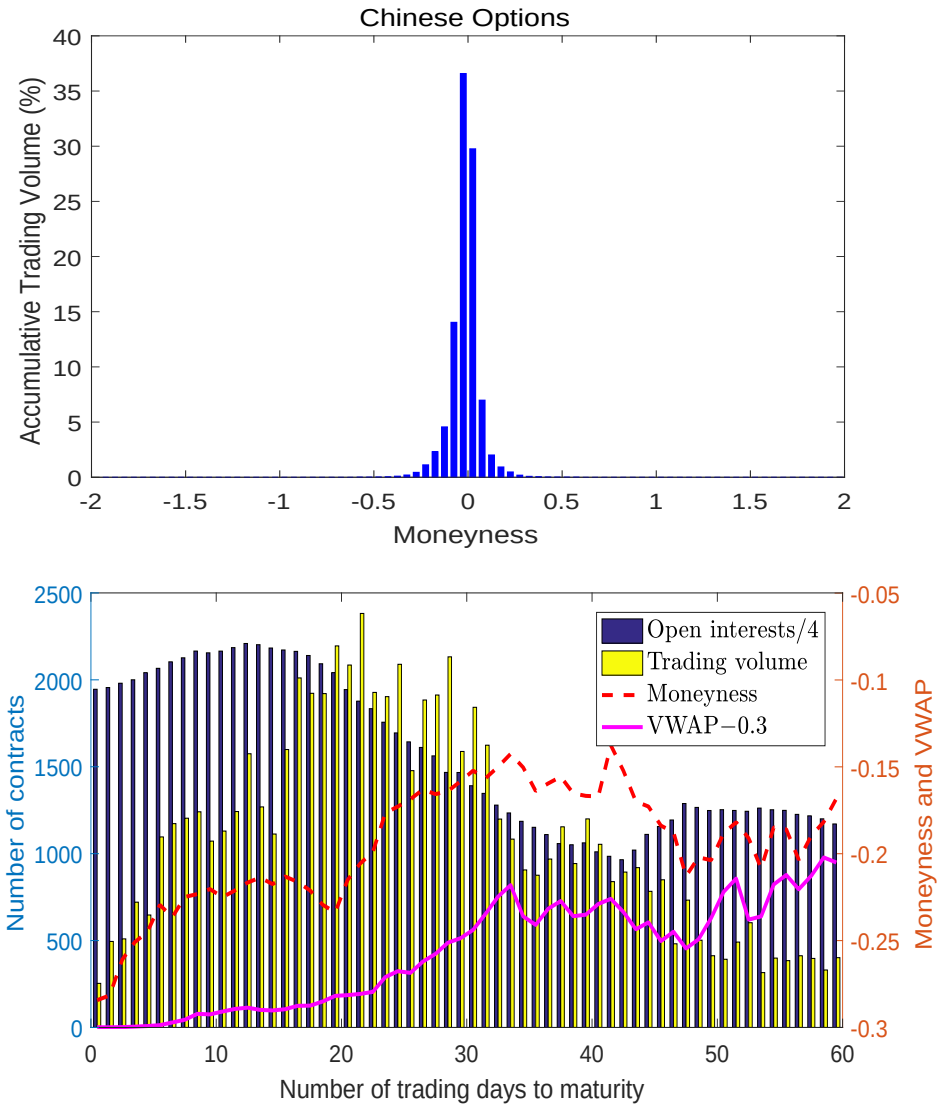

Figure OA.9: Trading Volume and Open Interest in Chinese Options Market. This figure shows statistics for trading volume and option interests of the current 50ETF options market in China. The top plot shows the aggregated trading volume (in percent) in each bin of moneyness. The bin size for moneyness is 0.05. The bottom plot shows average trading volume, average open interest, average moneyness, and average volume weighted average price (VWAP) for all deep OTM expired (moneyness on the last trading day lower than -0.2) options. Here we define moneyness as $\log(S_t/K)$ for calls, and as $-\log(S_t/K)$ for puts, where K is strike price and S_t is underlying price. The sample period for both plots is from February 9, 2015 through December 31, 2017.