EXERCISE TO LOSE MONEY? IRRATIONAL EXERCISE BEHAVIOR FROM THE CHINESE WARRANTS MARKET

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Using a market-level exercise data set and an individual-level trading data set between August 2006 and June 2009, this study examines the incidence of two types of irrational exercise behavior in the Chinese warrants market. We find that 121.64 million shares of warrants (0.64% of all warrants) were either exercised with an immediate loss or failed to be exercised, resulting in foregone risk-free profits. These irrational exercises caused warrant holders to lose over 717.79 million Yuan. Some of the irrational behavior can be attributed to "entertainment seeking" and the "T + 1" rule practiced in the Chinese security market, but the majority is attributed to warrant holders' ignorance and/or negligence of warrant mechanics. Our findings provide additional field evidence of clearly irrational exercise behavior in a derivatives market. We also find that investor education, information and guidance provision can mitigate the incidence of irrational exercise behavior significantly. © 2013 Wiley Periodicals, Inc. Jrl Fut Mark 34:399–419, 2014

1. INTRODUCTION

Evidence of behavioral mistakes in the financial markets is increasing. Given that increasing studies (Barber, Lee, Liu, & Odean, 2009; Barber, Odean, & Zhu, 2009; Hvidkjaer, 2008; Kaniel, Saar, & Titman, 2008; Kumar & Lee, 2006) show that such irrational behavioral patterns by investors can have substantial impact on price formation and liquidity in the securities markets, more needs to be known as to why investors make some seemingly simple mistakes.

One challenge in answering such a question is that prior studies rely heavily on specific assumptions about investor utility (Campbell, 2006; Dhar & Zhu, 2006; Grinblatt & Keloharju, 2001; Heath, Huddart, & Lang, 1999; Lee, Liu, & Zhu, 2008; Odean, 1998),

whereas derivatives markets provide a unique opportunity to study investor behavior because the valuation of many derivative securities can be calculated precisely without invoking particular assumptions about expectation or investor utility function. Following such logic, prior studies indeed document that investors fail to properly exercise American options before expiration in the U.S. options market (Diz & Finucane, 1993; Overdahl, 1988; Pool, Stoll, & Whaley, 2008). Although some studies point out that market friction and institutional considerations are responsible for the irrational exercise behavior (Dawson, 1996; Pool et al., 2008), Poteshman and Serbin (2003) show that part of the irrational exercise behavior can be attributed precisely to irrational behavioral decisions.

Building upon the previous studies on early option exercise behavior, the current study looks at a different aspect of optimal option exercise behavior in the context of the Chinese warrants market, where investors face a relatively simple decision upon warrant expiration: whether or not to exercise the warrants that they hold.[1]

Because the strike price and the market price of the underlying stock are easy to identify, it seems straightforward to decide whether to exercise a particular warrant. However, we indeed find that Chinese investors frequently fail to exercise valuable warrants upon expiration and sometimes exercise out-of-the-money warrants that cause them to lose money. Among all 39 warrants, we find irrational exercise behavior of some kind for 35 warrants (89.74% of the sample). In terms of the total number of expiring warrant shares, 121.64 million out of 19,002.12 million shares were identified as irrational exercise (0.64%). Our calculations reveal that investors have lost over 700 million Yuan (over 100 million USD) by failing to properly exercise the warrant contracts that they hold.

By investigating the incidence of irrational exercise behavior for different types of warrant contracts, we gain some insights for reasons behind the apparent irrational exercise behavior. First, we find that the "T + 1" delivery mechanism in the Chinese stock market is partly responsible for our findings. Because investors would have to hold the shares that they receive from warrant exercise for at least 1 day before they can liquidate such stocks in the stock market for call warrants and purchase the underlying shares at least one trading day prior to exercise for put warrants, they face potential risks from the next day price movement. Once we control for the 10% price movement limit in the next day of trading (the maximum potential risk one may face when deciding whether to exercise the warrant), the fraction of irrational exercise decreases to 0.53% of all warrant shares (from 0.64% when not accounting for the "T + 1" trading rule), yet still remains prevalent.

Secondly, we find that part of the irrational exercise behavior can be attributed to investors' lack of knowledge about warrant contracts and their lack of attention when warrant contracts come to expiration. Investors are far less likely to irrationally exercise their warrants at the Shenzhen Stock Exchange (0.10% of all warrant shares), which requires warrant issuers to publicly disclose the value of warrants and the optimal exercise decision upon expiration, than those at the Shanghai Stock Exchange (0.74% of all warrant shares), which does not impose similar requirement for information disclosure related to warrant exercise.

The current study provides two primary contributions to the extant literature. First, we provide some novel evidence of clearly irrational trading behavior when Chinese investors trade derivatives in the emerging derivatives market.

The Chinese warrants market creates at least three unique opportunities for studying irrational investor behavior. First, unlike other previously documented behavioral biases in investor trading that require certain assumptions about investors' utility functions (Dhar &

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[1]In general, the stock exchange or brokerage firms do not automatically exercise in-the-money warrants on behalf of investors.

Zhu, 2006; Heath et al., 1999; Odean, 1998; Sirri & Tufano, 1998; Zheng, 1999), our paper documents a clearly irrational behavior without invoking any specific assumptions for utility function (i.e., hyperbolic discounting) or risk aversion. Another advantage is that it is easier to identify optimal exercise decision in European and Bermudan options traded in China, as compared to American options studied in previous studies (Alpert, 2010; Diz & Finucane, 1993; Heath et al., 1999; Poteshman & Serbin, 2003). Further, investors should be better aware of optimal exercise decisions in China, since the stock exchanges, brokerage firms, and newspapers make optimal exercise decision readily available to all investors. Hence, the mistakes in Chinese investors' warrant exercise do not seem to result from high search costs, but less sophisticated investment skills instead. The existence of many such non-rational investors in the market during a 3-year period, questions the efficiency of the Chinese warrants market.

Second, our study points out two specific types of mistakes in investors' irrational exercise in the nascent Chinese warrants market. First, our findings that investors exercise clearly out-of-the-money warrants reveal that, different from the efficient market hypothesis assumptions, many investors trade derivative contracts that they do not fully understand, even if only simple algebra is required. Secondly, we find that investors' lack of attention (Barber & Odean, 2008) and negligence (Grinblatt & Keloharju, 2001) are probably a more important explanation of why so many valuable warrants were left unexercised.

Related to such findings on the sources of the costly irrational exercise behavior in the Chinese warrants market, the current study again emphasizes the importance of information search and investor protection in the financial markets. We find that investors are far less likely to make irrational exercise transactions for warrants listed at the Shenzhen Stock Exchange, where listed companies are required to disclose the value of the warrants and the proper way to exercise the warrants, than for warrants listed at the Shanghai Stock Exchange, where the above announcements are not required. Such findings stress that some easy-to-implement market regulations potentially can be very powerful in correcting investor mistakes and improving investor welfare.

Among the extant literature, the current study is closely related to a recent study by Poteshman and Serbin (2003) which documents frequent incidences of irrational early exercise behavior in the American options listed at the CBOE. The current study distinguishes from their study in two primary ways. First, unlike their study that examines (irrationally-) early exercise behavior with American options, the current study investigates investors' exercising or failure to exercise warrants upon expiration for Bermudan-style warrants in China. Because the question facing Chinese investors are relatively easier, we feel that documenting failure to properly exercise warrants in China may provide stronger evidence of irrational investor behavior in the derivatives markets.

Secondly, unlike their study investigating the behavior of different classes of investors in one of the most developed derivatives markets in the world, our study focuses on the behavior of (primarily retail) investors in a nascent derivatives market in China. Our findings not only confirm the irrational exercise behavior previously uncovered in the developed markets, but also enrich the literature by emphasizing how market design, investor knowledge, and information disclosure can influence such irrational behavior in a newly developed derivatives market in emerging markets.

The rest of the study proceeds as follows: Section 2 overviews the Chinese warrants market and the warrants exercise mechanism; Section 3 describes the market-wide and brokerage-level data on warrant exercise behavior; Section 4 outlines the primary research methodology implemented in the study; Section 5 presents our main empirical findings and discusses potential explanations for the irrational exercise behavior, before we conclude in Section 6.

2. THE CHINESE WARRANTS MARKET AND EXERCISE MECHANISM

2.1. The Chinese Warrants Market

The China Securities Regulatory Commission (CSRC) introduced a number of warrants that started trading in August 2005 as an initial step to open up the financial derivatives market and provide more investment vehicles to the Chinese securities markets. In some sense, stock warrants are considered close substitutes to stock options in China and the broader Asian financial markets.[2]

By August 2009, 18 put warrants and 37 call warrants had been issued to the public.[3] Both call and put warrants derive their values from the underlying stock prices: the value of a call warrant increases with the stock price, whereas that of a put warrant decreases. Several features of the Chinese warrants market distinguish it from the Chinese stock market. First, unlike stock trading, which is subject to the so called "T + 1" rule that requires investors to hold their stocks for at least 1 day before selling, warrants trading is subject to the "T + 0" rule, which allows investors to sell warrants they purchased earlier on the same day.

Second, investors incur lower transaction costs in warrant trading. In China, investors trading stocks typically pay a stamp tax to the government, a registration fee to the stock exchange, and a commission fee to brokerage firms for both sides of a round-trip transaction.[4] In contrast, investors trading warrants are exempt from paying any stamp tax and registration fee. Investors also tend to pay a lower commission fee to brokerage firms when trading warrants, during the sample period.

Third, the daily price change limit allows a wider range of price movement for warrants than for stocks. There is a 10% limit on daily price change of most stocks traded in the two stock exchanges.[5] With the large volatility in the Chinese stock market, individual stocks often reach their daily price change limit.[6] On the other hand, the daily permissible price change of a warrant is equal to the product of the daily permissible price change limit of the underlying stock in Yuan, the warrant's conversion ratio,[7] and a factor of 1.25.

2.2. Exercise Mechanism and Exercise Behavior

In the Chinese warrants market, investors are exempt from stamp tax, capital gains tax, registration fee and brokerage fee when exercising warrants and need only pay a settlement fee of 0.05% of the transaction amount. Warrants can be either cash- or stock-settled; but in practice, most are stock-settled.[8] Cash-settled warrants, which do not require the actual delivery of the underlying stocks, are automatically exercised on the expiration day if they are in-the-money after applying transaction costs. Since cash-settled warrants are automatically

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[2]Similar to the practice in Hong Kong and Taiwan, the warrants in China can be issued both by listed companies and a third party (e.g., a brokerage firm or a substantial shareholder). Also, some warrants do not result in additional equity issuance but end with buybacks from original issuers.

[3]There are also six warrants that are not allowed to be traded in the market.

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

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

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

[7]The conversion ratio is the number of shares of underlying stock that one share of warrant contract would deliver. The average conversion ratio is 1.08 and the median is 1 for our sample warrants.

[8]Among the 55 warrants, only one warrant was cash-settled.

exercised at maturity only if they are in-the-money, warrant holders are not required to deliver any exercise notice, and hence will not be subject to any bad decision or irrational exercise behavior.

In contrast, stock-settled warrants can be exercised only upon the holder's instruction, either if they are in-the-money or out-of-the-money. When exercising a stock-settled warrant, the holder should own enough cash (for call warrants) or shares of the underlying stock (for put warrants) before submitting the exercise instruction. The underlying stocks obtained from the exercise of a call warrant are subject to the "T + 1" rule and can be sold only on the next day of exercise or later. Similarly, underlying stocks bought on a particular day cannot be used to exercise a put warrant on the same day. If investors prefer more money to less, a warrant should only be exercised if it is in-the-money by at least as much as the fees and taxes for the underlying transaction.

There are two types of behavior which are not consistent with rational choice associated with the exercise of stock-settled warrants. First, investors fail to exercise valuable warrants and end up leaving money on the table. For example, some holders of an in-the-money warrant may fail to exercise the warrant before expiration. Secondly, it is also possible that investors exercise warrants even if it is not profitable to do so. In some cases, investors may exercise out-of-the-money warrants with losses instead of with profits. In other cases, investors may mistakenly exercise a warrant that is unprofitable to exercise after taking transaction costs into consideration. We define the above two types of irrational exercise behavior as "failure to exercise" and "faulty exercise," respectively, and consider both types as evidence of irrational exercise behavior.[9]

3. DATA DESCRIPTION

By August 2009, a total of 55 warrants had been issued and transacted on the Shanghai Stock Exchange and Shenzhen Stock Exchange. Out of the 55 warrants, 37 warrants were call warrants and the remaining 18 were put warrants. Classified based on the listing stock exchange, 39 warrants were listed in the Shanghai Stock Exchange and the remaining 16 were listed in the Shenzhen Stock Exchange.

Like options, warrants can be classified as American style (holder can exercise any time before the expiration date), European style (holder can exercise only on the expiration date), and Bermudan style (holder can exercise at a set number of days). The majority of the 55 warrants (49 warrants) were Bermudan style, with five warrants being European style and the remaining one being American style.

The first warrant, BaoSteel's call warrant (ticker name 580000.SH), was exercised on August 30, 2006. To keep a complete record on warrant exercise activities, we focus on warrants that expired before June 30, 2009. We exclude one cash-settled warrant that is subject to automatic exercise and one American-style warrant[10] and get a sample of 39 warrants. We obtain data on all of the 39 warrants from the RESSET Financial Research Database (www.resset.cn). Our data includes the basic information for each warrant (listing date, issuer, warrant type, underlying asset, exercise type, settlement type, duration period, and exercise period), daily price and trading information for warrants and underlying stocks (opening price, closing price, highest price, lowest price, and trading volume), daily exercise information (exercise price, conversion ratio, shares of warrants exercised, and cumulative shares of warrants exercised), and warrant origination and buy-back

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[9]Capital gains are exempt from taxation and should not influence the exercise decision for warrant holders in China.
[10]For American style warrant, the optimal exercise strategy is very complicated to determine.

TABLE I
Summary Statistics of the Sample

	Total	Call warrants	Put warrants
Panel A. Sample of warrants			
European Style	4	1	3
Bermudan Style	35	22	13
Total	39	23	16
Panel B. Time to maturity (calendar days)			
Mean	431.92	437.30	424.19
Median	365	365	365
SD	157.60	162.76	154.80
Panel C. Length of exercise period (calendar days)			
Mean	8.15	10.35	5.00
Median	7	7	5
SD	8.40	10.29	2.31
Panel D. Number of warrants that in-the-money and out-of-the-money at expiration			
Warrants in-the-money	19	19	0
Warrants Out-of-the-money	20	4	16

Note. This table provides the summary statistics of our sample. Time to maturity is calculated using the number of calendar days to expiration of the warrants. Length of exercise period is defined as the number of calendar days between the first and the last date of the exercise period. Warrants in-the-money and warrants out-of-the-money is defined based on the strike prices and the market prices of the underlying stocks at warrant expiration.

information[11] (shares of contracts originated, cumulative shares of contracts originated, shares of warrants bought back, and cumulative shares of warrants bought back).

The summary statistics of our sample are reported in Table I. Out of the 39 sample warrants, four warrants are European style (one call and three puts) and the remaining 35 are Bermudan style (22 calls and 13 puts). The average duration[12] of all the 39 warrants is 431.92 days with a median of 365 days. The average maturity of the call warrants is 437.3 days, whereas that for the put warrants is 424.19 days. The average length of exercise period is 8.15 days, with the average length of exercise period for call warrants (10.35 days) longer than that for put warrants (5 days). On the expiration date, 19 warrants (all are call warrants) are traded in-the-money and 20 warrants (four call warrants and 16 put warrants) are traded out-of-the-money.

As a supplement, we also use an individual-level trading data set which records all transactions and exercises of warrants for 2,060 retail investors at a large discount brokerage firm who have traded warrants over 2006–2009. The data come from the central information and technology center of the brokerage firm and has been verified and cross-checked for data accuracy and integrity. As Table II reported, 790 out of the 2,060 investors exercised at least one share of warrant, and the remaining 1,270 investors never exercised any warrant. The

[11]The Chinese warrants market experimented with a warrant origination mechanism by allowing a group of designated brokerage firms to create additional shares of warrants. The brokerage firms that originate additional warrants also have the option to buy back the additional warrants originated by the same brokerage firm. Because brokerage firms keep issuing new warrants and buying back newly created warrant contracts, the total net number of warrants issued on a stock changes over time. For greater details of the warrant origination mechanism, please see Liao et al. (2010).
[12]Here, duration means the life of a warrant, that is, the number of days from when it was first issued to when it expires.

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TABLE II

Summary Statistics of the Individual-Level Data

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	All warrants		Call warrants		Put warrants	
	Holding	*Exercise*	*Holding*	*Exercise*	*Holding*	*Exercise*
Panel A: Warrant contracts holding profile						
Number of investors	2,060	790	1,272	790	923	0
Number of warrants	39	22	23	22	16	0
Contract size (million shares)	31.9568	7.6612	11.2304	7.6612	20.7264	0
Contract value (million Yuan)	177.6163	35.7917	61.2381	35.7917	116.3782	0
	All investors		*Rational investors*		*Irrational investors*	
Panel B: Investor characteristics and stock trading behavior						
Gender	0.5744		0.5826		0.5442	
Age (year)	45.4851		45.5075		45.4033	
Experience (year)	7.6990		7.6780		7.7757	
Holdings size (Yuan)	105,805.65		111,538.61		82,840.96	
Number of stocks in portfolio	3.9864		3.9232		4.2395	
Turn over	6.7766		6.4894		7.9272	

Note. This table summarizes the holding profile of warrant contracts, the investor characteristics and stock trading behavior of the individual-level trading data set. The contract size is defined as the total number of warrant shares held (exercised) by the sample investors and is reported in million shares. The contract value is calculated as the sum product of the total number of warrant shares held (exercised) by the sample investors, market prices of the underlying shares on the last exercise day, and the corresponding warrant conversion ratios, and is reported in millions of Yuan. The dummy variable gender equals to 1 for males and 0 for females. The age variable reports how old an investor is in terms of year in 2009. Trading experience measures the number of years that an investor has traded until 2009. The holding size, numbers of stocks in portfolio and turn over are the average values in 2006–2009.

2,060 sample investors hold 31.96 million shares of warrants (11.23 million for call and 20.73 million for put), out of which 7.66 million shares (all are call warrants) were exercised. The notional amount of warrants[13] held and exercised by the sample investors are 177.61 and 35.79 million Yuan, respectively. Table II also reports the major characteristics and stock trading behavior of the investors of the individual-level data.

4. METHODOLOGY

In this section, we describe our research methodology. As discussed in Section 2.2, we can identify two types of irrational exercise behavior, "failure to exercise" and "faulty exercise." "Failure to exercise" denotes the cases when investors failed to exercise some warrant contracts that should be exercised before expiration. "Faulty exercise" denotes the cases when investors exercised some warrant contracts that should not be exercised. Whereas it is conceivable that "failure to exercise" may be passive and may result from investor inattention or negligence, "faulty exercise" requires some active actions taken by the investors and provides strong evidence on the irrational investor behavior. Based on the above argument, we expect "failure to exercise" to take place more often than the case of "faulty exercise."

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[13]The notional amount of warrants for a specific warrant is equal to the sum product of the total shares of warrants, market price of the underlying stock on the expiration day, and the warrant's conversion ratio.

It is worth noting that the decision to exercise or not to exercise potentially could be impacted by underlying transaction costs. In the Chinese warrants market, investors incur a lower transaction cost when transferring stocks through exercising stock warrants. When trading stocks, investors pay a stamp tax, a registration fee, and a brokerage fee.[14] Investors exercising warrants are exempted from paying any stamp tax, registration fee, or brokerage fee. But they still need to pay a settlement fee of 0.05% of the total proceeds. With these considerations, we next specify the conditions for the two types of irrational exercise behavior.

Failure to exercise: Some in-the-money warrant contracts (i.e., a call warrant with strike price less than the market price of the underlying stock or a put warrant with strike price greater than the market price of the underlying stock) go unexercised before expiration.

Under the weak assumption that investors prefer more money to less and would choose to exercise a call (put) warrant when the market price of the underlying stock is above (below) the strike price (Poteshman & Serbin, 2003), "failure to exercise" can be relatively easily identified by comparing the strike price and the market price of the underlying stock for European warrants. However, it is not as straightforward to identify the case of "failure to exercise" for Bermudan warrants since they can be exercised on a set number of days. With strict criteria, failure to exercise an in-the-money warrant within the optimal exercise period is considered irrational. Since determining the optimal exercise boundary is beyond the sophistication of most investors, as well as the scope of this study, we will not classify an exercise as irrational if it is in-the-money but not aligned to the optimal exercise boundary. Consequently, we calculate the total number of warrant shares and fraction of warrant shares that were not exercised after expiration for each warrant that is in-the-money after considering commissions and taxes at least on the last exercise day. With this criteria, some irrational exercises before the last exercise day can be classified as rational.

The call warrant holder must pay a commission, a stamp tax and a second commission when selling the stock shares received through warrant exercising. In particular, a case is classified as "failure to exercise" if a call warrant is not exercised before expiration when the following inequality is satisfied:

$$S_T \times (1 - tax - comm_2) - X_{C,T} \times (1 + comm_1) > 0, \qquad (1)$$

where T denotes the expiration date of the warrant; S_T denotes the market price of the underlying stock for the call warrant; $X_{C,T}$ denotes the warrant strike price on the expiration date[15]; $comm_1$ and $comm_2$ denote the commission charges in percentage that apply to exercise of a warrant and purchase (or sale) of the underlying stock, respectively; tax is the rate of stamp tax that applies to purchase (or sale) of the underlying stock.

To exercise a put warrant, the warrant holder must buy appropriate shares of the underlying stock beforehand. In particular, a case is classified as "failure to exercise" if a put warrant is not exercised before expiration and the following inequality is satisfied:

$$X_{P,T} \times (1 - comm_1) - S_T \times (1 + tax + comm_2) > 0, \qquad (2)$$

where $X_{P,T}$ denotes the strike price on the expiration day for the put warrant, S_T denotes the market price of the underlying stock for the put warrant.

Faulty exercise: Some out-of-the-money warrant contracts (i.e., a call warrant with strike price greater than the market price of the underlying stock or a put warrant with strike price less than the market price of the underlying stock) are exercised.

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[14]Please refer to Section 2.1 for details.
[15]The strike price of a warrant contract may change over time due to dividend payment or stock split of the underlying stock.

The case of "faulty exercise" can be identified in a similar way to that of "failure to exercise." After applying commissions and taxes, if the warrant holder could buy the underlying stocks in the spot market at a lower cost, or sell the underlying stocks in the spot market at a higher value, exercising the warrant is considered "irrational." Hence, an exercising transaction is considered as an irrational "faulty exercise" if it satisfies one of the following inequalities:

$$X_{C,t} \times (1 + comm_1) > S_t \times (1 + tax + comm_2), \tag{3}$$

$$X_{P,t} \times (1 - comm_1) < S_t \times (1 - tax - comm_2), \tag{4}$$

where t denotes the time when a particular exercise is delivered; $X_{C,t}$ and $X_{P,t}$ denote the strike price at time t for a call and put warrant, respectively; S_t denotes the market price of the underlying stock at time t.[16]

One point worth noting is that the exercise information provided by the RESSET Financial Research Database is at the aggregate daily level. Since the intraday tick by tick exercise data is not available, we cannot get the exact market price of the underlying stock when a particular exercise is made. Therefore, we use the closing price of the underlying stock to estimate S_t. In unreported analysis, we perform a number of robustness tests by using the opening price, the highest price and the lowest price of the underlying stock to estimate S_t, and obtain very similar results.

5. EMPIRICAL RESULTS

5.1. Incidence of Irrational Exercise

For the purpose of studying irrational exercise behavior, we focus on warrants that are clearly in-the-money and those that are clearly out-of-the-money upon expiration. Panel D of Table I indicates that, according to our calculation based on the methodology described in Section 4, 19 warrants are categorized as warrants hat should be exercised, and the remaining 20 warrants are categorized as warrants that should not be exercised.

We first investigate the frequency of irrational exercise for both "failure to exercise" and "faulty exercise." As Panel A of Table III shows, out of the total 39 sample warrants (23 calls and 16 puts) 35 warrants (23 calls and 12 puts) experienced irrational exercise. The ratio of warrants that experienced irrational exercise to all warrants is 89.74% (100% for call warrants and 75% for put warrants).

In addition to the number of warrants, we also examined the number of warrant shares that were irrationally exercised. A total of 121.64 million warrant shares (121.28 million for call warrants and 0.36 million for put warrants) were irrationally exercised, which constitute 0.64% (1.40% for call warrants and 0.004% for put warrants) of the total number of warrant shares.

We next perform the same exercises for the respective sample of warrants that should be exercised and warrants should not be exercised. Our analysis in Panel B of Table III reveals that all of the 19 warrants that should be exercised experienced irrational exercise. It is worth noting that all these 19 warrants were call warrants and not a single put warrant remains in-the-money at the time of expiration. This is probably directly related to the sharp market

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[16]Unlike to "failure to exercise," which is assessed on the expiration date of a warrant, "faulty exercise" is assessed throughout the exercise period of a warrant.

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TABLE III
Irrational Exercise

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	Number of warrants			Shares of warrants (million shares)		
	Total	Call	Put	Total	Call	Put
Panel A. All warrants						
Total	39	23	16	19,002.1197	8,663.2391	10,338.8806
Irrational exercise	35	23	12	121.6373	121.2792	0.3581
Fraction (%)	89.74	100.00	75.00	0.6401	1.3999	0.0035
Panel B. Warrants that should be exercised						
Total	19	19	0	7,194.8891	7,194.8891	0
Failure to exercise	19	19	0	115.1817	115.1817	0
Fraction (%)	100.00	100.00	—	1.6009	1.6009	—
Panel C. Warrants that should not be exercised						
Total	20	4	16	11,807.2306	1,468.3500	10,338.8806
Faulty exercise	16	4	12	6.4556	6.0976	0.3581
Fraction (%)	80.00	100.00	75.00	0.0547	0.4153	0.0035

Note. This table reports the incidence and fraction of irrational exercise behavior for both cases of "failure to exercise" and "faulty exercise." A case is considered as irrational "failure to exercise" when a call warrant is not exercised before expiration and $S_T \times (1 - tax - comm_2) - X_{C,T} \times (1 + comm_1) > 0$, or a put warrant is not exercised before expiration and $X_{P,T} \times (1 - comm_1) - S_T \times (1 + tax + comm_2) > 0$, where T denotes the expiration date of the warrant; S_T denotes the market price of the underlying stock; $X_{C,T}$ and $X_{P,T}$ denote the strike price on the expiration date for a call warrant and a put warrant, respectively; $comm_1$ and $comm_2$ denote the commission charges in percentage that apply to exercise of a warrant and purchase (or sale) of the underlying stock, respectively; tax is the rate of stamp tax that applies to purchase (or sale) of the underlying stock. An exercise is classified as an irrational "faulty exercise" if $X_{C,t} \times (1 + comm_1) > S_t \times (1 + tax + comm_2)$ or $X_{P,t} \times (1 - comm_1) < S_t \times (1 - tax - comm_2)$, where t denotes the time when a particular exercise is delivered.

surge in the 2006–2007 periods. In terms of total number of warrant shares, 115.18 million out of the total of 7,194.89 million shares (1.60%) were not exercised before expiration.

We further examine the incidents for the sub-sample of warrants that should not be exercised and obtain consistent results that investors made apparent mistakes in exercising such out-of-the-money warrants. Sixteen out of the total 20 warrant (4 out of the 4 call warrants and 12 out of the 16 put warrants) experienced "faulty exercise." In terms of the total number of shares, 6.46 million out of the 11,807.23 million warrant shares (0.05%) experienced "faulty exercise." In addition, "faulty exercise" occurs far more often for call warrants (6.10 million out of the 1,468.35 million call warrant shares or 0.42%) than for put warrants (0.36 million out of 10,338.88 million put warrant shares or 0.004%).

In sum, our results show that a considerably large number of warrant shares were irrationally exercised under both categories of irrational exercise.

5.2. Wealth Being Lost

Now that we have documented the incidence of irrational exercise in the Chinese warrants market, we next set out to estimate the wealth being lost because of such irrational exercise behavior.

For "failure to exercise," we calculate the wealth being lost by comparing the exercise price and the closing price of the underlying stock on the last exercise day for each warrant that should be exercised, the difference is then multiplied by the total shares of warrant that

investors failed to exercise. In particular, the total wealth being lost for call warrants and put warrants is calculated as

$$Lost_{Failure\ to\,exercise,\ call} = \sum_{i=1}^{N} n_i \times ratio_i \times (S_{T,i} - X_{T,i}), \tag{5}$$

$$Lost_{Failure\ to\ exercise,\ put} = \sum_{i=1}^{N} n_i \times ratio_i \times (X_{T,i} - S_{T,i}), \tag{6}$$

where n_i is the total shares of warrant that were not exercised before expiration for the ith warrant that should be exercised; $ratio_i$ is the conversion ratio of the ith warrant, $S_{T,i}$ is the closing price of the underlying stock on the expiration day; $X_{T,i}$ is the warrant exercise price on the expiration day; N is the number of warrants that should be exercised.

Similarly, for "faulty exercise," the wealth being lost for each warrant is calculated by multiplying the shares of warrant that were faultily exercised and the difference between the market price of the underlying stock and the exercise price on the exercise day. Specifically, the total wealth being lost is calculated as

$$Lost_{Faulty\ exercise,\ call} = \sum_{i=1}^{N} n_i \times ratio_i \times (X_{t,i} - S_{t,i}), \tag{7}$$

$$Lost_{Faulty\ exercise,\ put} = \sum_{i=1}^{N} n_i \times ratio_i \times (S_{t,i} - X_{t,i}), \tag{8}$$

where n_i is the total shares of warrant that were exercised for the ith warrant that should not be exercised; $ratio_i$ is the conversion ratio of the ith warrant; t denotes the time when a particular exercise is delivered; $X_{t,i}$ and $S_{t,i}$ denote the ith warrant' strike price and the market price of the underlying shock at time t, respectively; N is the number of warrants that should not be exercised.

As Table IV suggests, the total wealth being lost for the two types of irrational exercise behavior is 717.79 million Yuan (714.64 million Yuan for call warrants and 3.15 million Yuan for put warrants). Out of the 717.79 million Yuan, 712.32 million Yuan is attributable to the irrational behavior of "failure to exercise" (all for call warrants), and the remaining 5.47 million Yuan is attributable to the irrational behavior of "faulty exercise" (2.32 million Yuan for call warrants and 3.15 million Yuan for put warrants). We also report the total wealth lost after considering the maximum possible transaction costs in Table IV and find that transaction costs have a negative but insignificant impact on wealth loss.

5.3. Discussions of Alternative Explanations

Now that we have documented that a large number of warrant exercises are clearly irrational and these irrational exercises have caused warrant holders to lose considerable wealth, we next explore the natural question of what is responsible for such seemingly irrational exercise behavior for both "faulty exercise" and "failure to exercise."

5.3.1. Market friction and the "T + 1" trading mechanism

As discussed in Section 2, the Chinese stock market follows the so called "T + 1" rule, under which the delivery of security takes place 1 day after the transaction. As a result, stocks purchased on a day cannot be used to exercise a put warrant on the same day. In the same spirit, investors cannot sell the underlying stocks obtained from exercising call warrants until the next trading day. This practice may impact the exercise decision of some warrant holders.

TABLE IV
Wealth Being Lost from Irrational Exercise (Million Yuan)

	Total	Failure to exercise	Faulty exercise
Wealth loss before costs			
Total	717.7874	712.3164	5.4711
Call	714.6404	712.3164	2.3240
Put	3.1471	0	3.1471
Wealth loss after costs			
Total	709.8171	704.5236	5.2936
Call	706.6976	704.5236	2.1740
Put	3.1196	0	3.1196

Note. This table reports the total wealth being lost for the two types of irrational exercise behavior. For the case of "failure to exercise," the total wealth being lost is calculated as $Lost_{call} = \sum_{i=1}^{N} n_i \times ratio_i \times (S_{T,i} - X_{T,i})$ and $Lost_{put} = \sum_{i=1}^{N} n_i \times ratio_i \times (X_{T,i} - S_{T,i})$ for call and put warrants, respectively, where T denotes the expiration date of the warrant; n_i is the total shares of warrants that were not exercised before expiration for the ith warrant; $ratio_i$ is the conversion ratio; $S_{T,i}$ is the closing price of the underlying stock; $X_{T,i}$ is the exercise price; N is the number of warrants that should have been exercised. For the case of "faulty exercise," the total wealth being lost for call warrants and put warrants is calculated as $Lost_{call} = \sum_{i=1}^{N} n_i \times ratio_i \times (X_{t,i} - S_{t,i})$ and $Lost_{put} = \sum_{i=1}^{N} n_i \times ratio_i \times (S_{t,i} - X_{t,i})$, respectively, where t denotes the time when a particular exercise is delivered; N is the number of warrants that should not have been exercised. When calculating the total wealth loss after costs, we apply the maximum possible cost for stamp tax for stock trading (0.3%), commission charges for stock trading (0.3%), and commission charges for warrant exercising (0.05%) that practiced in the Chinese market.

Because the "T + 1" rule should matter only to warrants that should be exercised, we expect that accounting for the trading rule would influence our results only on warrants that originally should be exercised ("failure to exercise") but not on warrants that should not be exercised ("faulty exercise").[17]

For example, with a bearish view on the underlying stock in the following trading day, a rational investor may choose not to exercise a slightly in-the-money call warrant. Instead, the investor may believe that the price drop in the following trading day, the earliest time for realizing the trading profit in the spot market, may be so large that it may overtake the nominal profits that would be obtained from the warrant exercise and cause net losses. Fortunately for the purpose of our study, there is a daily price movement limit of 10% for almost all stocks traded in the Chinese stock market. Consequently, we adjust the criteria for defining irrational exercising when taking into consideration of the "T + 1" rule and potential price decrease in underlying stocks. In particular, inequality Equation (1) can be rewritten as:

$$S_T \times (1 - tax - comm_2) \times (1 - change) \times e^{-r/365} - X_{C,T} \times (1 + comm_1) > 0, \quad (9)$$

where *change* is the daily price movement limit of the underlying stock, r is the risk-free rate, and $e^{-r/365}$ is the discount factor for 1 day (we assume there are 365 days per year).[18]

Unlike with a call warrant, an investor planning to exercise a put warrant must purchase enough underlying shares at least 1 day before. Accordingly, we modify our criteria to define "failure to exercise" for put warrants and re-write inequality Equation (2) as follows:

$$X_{P,T} \times (1 - comm_1) - S_{T-1} \times (1 + tax + comm_2) \times e^{r/365} > 0. \quad (10)$$

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[17]Because the "T + 1" trading rule impacts the profit profile of stocks received (sold) by warrant exercise and stocks purchased (sold) in the spot market in exactly the same way, we believe that the "T + 1" trading rule does not affect the occurrence of faulty exercise.

[18]We implemented alternative discounting rule with 252 trading days and our main results remain.

TABLE V
Irrational Exercise After Taking Account of the "T + 1" Rule

	Number of warrants			Shares of warrants (million shares)		
	Total	Call	Put	Total	Call	Put
Panel A. All warrants						
Total	37	21	16	17,632.7818	7,293.9012	10,338.8806
Irrational exercise	33	21	12	93.0686	92.7106	0.3581
Fraction (%)	89.19	100.00	75.00	0.5278	1.2711	0.0035
Panel B. Warrants should be exercised						
Total	17	17	0	5,825.5512	5,825.5512	0
Failure to exercise	17	17	0	86.6130	86.6130	0
Fraction (%)	100.00	100.00	—	1.4868	1.4868	—
Panel C. Warrants should not be exercised						
Total	20	4	16	11,807.2306	1,468.3500	10,338.8806
Faulty exercise	16	4	12	6.4556	6.0976	0.3581
Fraction (%)	80.00	100.00	75.00	0.0547	0.4153	0.0035

Note. This table reports the incidence and fraction of irrational exercise after taking account of the "T + 1" rule and potential price decrease in underlying stocks. A case is considered as irrational "failure to exercise" when a call warrant is not exercised before expiration and $S_T \times (1 - tax - comm_2) \times (1 - change) \times e^{-r/365} - X_{C,T} \times (1 + comm_1) > 0$, or a put is not exercised before expiration and $X_{P,T} \times (1 - comm_1) - S_{T-1} \times (1 + tax + comm_2) \times e^{r/365} > 0$, where T denotes the expiration date of the warrant; S_T denotes the market price of the underlying stock; $X_{C,T}$ and $X_{P,T}$ denote the warrant strike price on the expiration date for a call and put warrant, respectively; $comm_1$ and $comm_2$ denote the commission charges in percentage that apply to exercise of a warrant and purchase (or sale) of the underlying stock, respectively; tax is the rate of stamp tax that applies to purchase or sale of the underlying stock; $change$ is the daily price movement limit of the underlying stock; r is the risk-free rate, and $e^{-r/365}$ is the discount factor for 1 day. An exercise is classified as an irrational "faulty exercise" if $X_{C,t} \times (1 + comm_1) > S_t \times (1 + tax + comm_2)$ or $X_{P,t} \times (1 - comm_1) < S_t \times (1 - tax - comm_2)$, where t denotes the time when a particular exercise is delivered.

We report our new results based on these new criteria accounting for the "T + 1" trading rule in Table V. Our results confirm that the "T + 1" rule can explain part of the irrational exercise behavior. Compared with the results in Table III, some noticeable decreases are realized in both the incidence and fraction of irrational exercise. The total number of warrants that experienced irrational exercise decreases to 33 from 35 after accounting for the "T + 1" rule. The total number of warrant shares that were irrationally exercised decreases to 93.07 million from 121.64 million, driving the fraction of irrationally exercised warrant shares among all expired warrant shares from 0.64% to 0.53%.

As argued previously, we expect that the new criteria affect only our results on warrants that should have been exercised originally ("failure to exercise"), but not on warrants that should not be exercised ("faulty exercise"). This is exactly what we have found. For warrants that are profitable to exercise, the total number of warrants that experienced irrational exercise decreases to 17 from 19. Consistently, the total number of warrant shares that were irrationally exercised decreases to 86.61 million (1.49%) from 115.18 million (1.60%). At the same time, the total number of warrants and the total number of warrant shares that were "faultily exercised" remain unchanged from those in Table III, after considering the "T + 1" rule.

Collectively, our above analysis indicates that the "T + 1" rule practiced in China and the potential decrease in future stock prices play some roles in explaining investors' failure to exercise. However, more importantly, our additional analysis confirms our main findings and

the prevalent existence of a considerable number of irrationally exercised warrants, despite controlling the influence of the "T + 1" rule.

5.3.2. Ignorance of warrant mechanics and negligence

Pool et al. (2008) document that some U.S. option holders have failed to exercise in-the-money call options on ex-dividend days when it is optimal to do so. They argue that the failure to exercise in many cases implies that option holders are unaware of the desirability of early exercise, lazy in the monitoring of their positions, and/or simply irrational.

Given that warrants trading were reintroduced only recently in the Chinese financial markets during our sample period,[19] we feel that it is likely that some investors do not fully understand the mechanics of warrant trading and therefore fail to trade properly. This can be reflected to some extent by previous studies (Liao, Li, Zhang, & Zhu, 2010; Xiong & Yu, 2011) that Chinese investors ignore the fundamentals of warrants and trade aggressively on warrants that were about to expire within a trading day. In addition, Liao et al. (2010) and Liao, Li, Zhang, and Zhu (2012) show that Chinese retail investors are relatively young in age and many of them lack trading experiences. Such a lack of knowledge and sophistication may also be responsible for the apparently irrational trading behavior that we witness in the current study.

The differences between the two stock exchanges in China provide us an interesting opportunity to examine the impact of investor education and information dissemination on investment behavior. As indicated in Section 2, there are two similar exchanges in China, the Shanghai Stock Exchange and the Shenzhen Stock Exchange. Although subject to the same governance and regulatory structure, the two exchanges have different requirements for information disclosure related to warrant exercise.

The Shenzhen Stock Exchange imposes a more strict exercise information disclosure practice than the Shanghai Stock Exchange does. For example, The Shenzhen Stock Exchange requires the issuers to release an announcement of expiration 2 months, 1 month, 3 weeks, 2 weeks, 1 week, 5 days, and 3 days before the exercise period, whereas the Shanghai Stock Exchange only requires warrant issuers to announce expiration reminders 3 days and 1 day before expiration. Further, the Shenzhen Stock Exchange requires warrant issuers to explain fully the risk and return of warrant exercise and inform investors how to exercise 7 and 3 days before the exercise period, whereas the Shanghai Stock Exchange does not impose a similar requirement.

As a result, studying the incidence and distribution of irrational exercise across the two exchanges provides a unique opportunity to investigate the influences that investors' awareness and understanding of warrant mechanics on their irrational exercise behavior. If warrant holders irrationally exercised or failed to exercise warrant because of less awareness and understanding, we would expect that warrants listed in the Shanghai Stock Exchange are more likely to witness irrational exercise, that is, out-of-money warrants are exercised or in-the-money warrants are left unexercised irrationally than warrants listed in the Shenzhen Stock Exchange. To test this hypothesis, we investigate the incidence of irrational exercise and frequency of irrational exercise at respective stock exchanges and report the results in Table VI.

Panel A of Table VI shows that the frequency of irrational exercise for warrants listed in the Shanghai Stock Exchange is 0.74%, whereas that for warrants listed in the Shenzhen Stock Exchange is much smaller at 0.1%. Panels B and C of Table VI report results consistent with those in Panel A, with subsamples of warrants that should be exercised and warrants that should not be exercised. For warrants that should be exercised, the frequency of irrational

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[19]Few warrants were introduced and the banned soon afterwards in 1992 at the beginning of the Chinese stock market.

TABLE VI
Irrational Exercise in Different Exchanges

	Shanghai Exchange		Shenzhen Exchange	
	Rational exercise	Irrational exercise	Rational exercise	Irrational exercise
Panel A. All warrants				
Shares (million shares)	11,674.6296	87.2392	5,865.0836	5.8294
Fraction (%)	99.2583	0.7417	99.9007	0.0993
Chi-squared test		<0.0001		
Panel B. Warrants should be exercised				
Shares (million shares)	4,175.5443	80.8381	1,563.3939	5.7750
Fraction (%)	98.1008	1.8992	99.6320	0.3680
Chi-squared test		<0.0001		
Panel C. Warrants should not be exercised				
Shares (million shares)	7,499.0853	6.4012	4,301.6897	0.0544
Fraction (%)	99.9147	0.0853	99.9987	0.0013
Chi-squared test		<0.0001		

Note. This table reports the incidence and fraction of irrational exercise at the Shanghai Stock Exchange and the Shenzhen Exchange, respectively. A case is considered as irrational "failure to exercise" when a call warrant is not exercised before expiration and $S_T \times (1 - tax - comm_2) \times (1 - change) \times e^{-r/365} - X_{C,T} \times (1 + comm_1) > 0$, or a put is not exercised before expiration and $X_{P,T} \times (1 - comm_1) - S_{T-1} \times (1 + tax + comm_2) \times e^{r/365} > 0$, where T denotes the expiration date of the warrant; S_T denotes the market price of the underlying stock; $X_{C,T}$ and $X_{P,T}$ denote the warrant strike price on the expiration date for a call and put warrant, respectively; $comm_1$ and $comm_2$ denote the commission charges in percentage that apply to exercise of a warrant and purchase (or sale) of the underlying stock, respectively; tax is the rate of stamp tax that applies to purchase or sale of the underlying stock; $change$ is the daily price movement limit of the underlying stock; r is the risk-free rate, and $e^{-r/365}$ is the discount factor for 1 day. An exercise is classified as an irrational "faulty exercise" if $X_{C,t} \times (1 + comm_1) > S_t \times (1 + tax + comm_2)$ or $X_{P,t} \times (1 - comm_1) < S_t \times (1 - tax - comm_2)$, where t denotes the time when a particular exercise is delivered. Chi-squared tests are performed for comparing the frequency of irrational exercise in the two stock exchanges.

exercise is 1.9% for Shanghai-listed warrants and 0.37% for Shenzhen-listed warrants. For warrants that should not be exercised, the frequency of irrational exercise is 0.09% for Shanghai-listed warrants, which again is much greater than that for Shenzhen-listed warrants (0.001%). Because the sample size is small and the sample distributions do not conform to the normal distribution, we perform additional Chi-Squared tests to determine whether the frequency of irrational exercise in the Shanghai Stock Exchange differs significantly from that in the Shenzhen Stock Exchange. We find that all above differences are significant at the 1% level, which provides further support to our hypothesis that warrants listed in Shanghai are more likely to experience irrational exercise, for both cases of "failure to exercise" and "faulty exercise."

Next, we examine the incidence and frequency of irrational exercise for warrants with different length of exercise period. Particularly, we use the median length of exercise period of all sample warrants as the cutoff value and divide the sample warrants into two subsamples.[20] Because investors have less time to process the information about warrant expiration or to understand the situation and make the correct exercise decision, we expect that warrants with a shorter exercise period are more likely to be irrationally exercised or unexercised than warrants with a longer exercise period. This is indeed what we have found.

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[20]In unreported analysis, we perform a robustness test by using the average length of exercise period as the cutoff value and our main results remain the same.

TABLE VII
Irrational Exercise for Warrants with Different Exercise Periods

	Exercise period <7 days		Exercise period ≥7 days	
	Rational exercise	Irrational exercise	Rational exercise	Irrational exercise
Panel A. All warrants				
Shares (million shares)	7,697.6691	50.8891	9,842.0441	42.1796
Fraction (%)	99.3432	0.6568	99.5733	0.4267
Chi-squared test		<0.0001		
Panel B. Warrants should be exercised				
Shares (million shares)	1,023.0881	45.1090	4,715.8501	41.5040
Fraction (%)	95.7771	4.2229	99.1276	0.8724
Chi-squared test		<0.0001		
Panel C. Warrants should not be exercised				
Shares (million shares)	6,674.5810	5.7801	5,126.1940	0.6755
Fraction (%)	99.9135	0.0865	99.9868	0.0132
Chi-squared test		<0.0001		

Note. This table reports the incidence and fraction of irrational exercise for warrants with different lengths of exercise period. Length of exercise period is defined as the number of calendar days between the first and the last date of the exercise period. A case is considered as irrational "failure to exercise" when a call warrant is not exercised before expiration and $S_T \times (1 - tax - comm_2) \times (1 - change) \times e^{-r/365} - X_{C,T} \times (1 + comm_1) > 0$, or a put is not exercised before expiration and $X_{P,T} \times (1 - comm_1) - S_{T-1} \times (1 + tax + comm_2) \times e^{r/365} > 0$, where T denotes the expiration date of the warrant; S_T denotes the market price of the underlying stock; $X_{C,T}$ and $X_{P,T}$ denote the warrant strike price on the expiration date for a call and put warrant, respectively; $comm_1$ and $comm_2$ denote the commission charges in percentage that apply to exercise of a warrant and purchase (or sale) of the underlying stock, respectively; tax is the rate of stamp tax that applies to purchase or sale of the underlying stock; $change$ is the daily price movement limit of the underlying stock; r is the risk-free rate, and $e^{-r/365}$ is the discount factor for 1 day. An exercise is classified as an irrational "faulty exercise" if $X_{C,t} \times (1 + comm_1) > S_t \times (1 + tax + comm_2)$ or $X_{P,t} \times (1 - comm_1) < S_t \times (1 - tax - comm_2)$, where t denotes the time when a particular exercise is delivered. Chi-squared tests are performed for comparing the frequency of irrational exercise behavior on warrants with a longer and shorter exercise period.

As indicated in Panel A of Table VII, the frequency of irrational exercise for warrants with a shorter exercise period (0.66%) is significantly greater than that (0.43%) for warrants with a longer exercise period at the 1% level. Panels B and C of Table VII report results with subsamples of warrants that should be exercised and warrants that should not be exercised. For the subsample of warrants that should be exercised, the frequency of irrational exercise is 4.22% for warrants with a shorter exercise period and higher than that (0.87%) for warrants with a longer exercise period. Consistently for the subsample of warrants that should not be exercised, the frequency of irrational exercise is 0.09% for warrants with a shorter exercise period and 0.01% for warrants with a longer exercise period. All above differences are again highly significant at the 1% level.

Further, we perform a multivariate regression analysis of the impact of exchange and exercise period on irrational exercise behavior as follows:

$$Freq_i = b_0 + b_1 \times Type_i + b_2 \times Exchange_i + b_3 \times Short_i + b_4 \times Exercise\_Price_i + b_5 \times Stock\_Price_i + b_6 \times Float_i + b_7 \times Duration_i$$

The dependent variable $Freq_i$ is the frequency of irrational exercise of warrant i. There are three independent dummy variables, $Type_i$, $Exchange_i$, and $Short_i$. $Type_i$ takes a value of one for a call warrant and zero otherwise. $Exchange_i$ takes a value of one if a warrant is traded

TABLE VIII
Multivariate Regression

Variable	Reg 1: All warrants	Reg 2: Warrants should be exercised	Reg 3: Warrants should not be exercised
Intercept	0.0006 (0.03)	−0.0527 (−1.44)	0.0050 (1.36)
$Type_i$	0.0187 (1.88)*	/	0.0079 (2.67)**
$Exchange_i$	0.0109 (1.05)	0.0587 (2.98)***	−0.0005 (−0.22)
$Short_i$	0.0140 (1.56)	0.0554 (3.33)***	0.0013 (0.70)
$Exercise\_Price_i$	−0.0017 (−1.34)	−0.0046 (−1.77)*	−0.0005 (−1.38)
$Stock\_Price_i$	0.0003 (0.80)	0.0002 (0.34)	0.0001 (1.18)
$Float_i$	−0.0000 (−0.50)	−0.0000 (−1.57)	−0.0000 (−0.34)
$Duration_i$	−0.0000 (−0.52)	0.0001 (1.81)*	−0.0000 (−1.39)
# of observations	37	17	20
Adj. R^2	0.1109	0.4406	0.1854

Note. This table shows the regression results with frequency of irrational exercise as the dependent variable. $Type_i$ is a dummy variable that takes a value of one for a call warrant and zero for a put warrant. $Exchange_i$ is dummy variable that takes a value of one if a warrant is traded in the Shanhgai Stock Exchange and zero otherwise. $Short_i$ is a dummy variable that takes a value of one if the exercise period of a warrant is short (less than 7 days) and zero otherwise. *Float* is the total number of warrants outstanding. $Duration_i$ is calculated using the number of calendar days to warrant expiration. T-statistics are in parentheses.
***, **, *Indicates significantly different from zero at the 1%, 5%, and 10% level, respectively.

in the Shanghai Stock Exchange. $Short_i$ takes a value of one if the exercise period of a warrant is short (less than 7 days). $Float_i$ is the total shares of warrants outstanding. $Duration_i$ is calculated using the number of calendar days to warrant expiration.

We report the regression results in Table VIII.[21] Most interesting to the focus of the exercise, we find that the coefficient of the $Short_i$ dummy variable is positive for all of the three samples, and is statistically significant for the sample of warrants that should be exercised. Consistent with our univariate analysis, such results suggest that a shorter exercise period is associated with a greater fraction of faulty exercise. We also obtain indicative results for the coefficients of the $Exchange_i$ dummy variable.

All the above results confirm our conjecture that the irrational exercise behavior in the Chinese warrants market can be partly explained by investors' lack of understanding about the fundamental value of warrants and investors' lack of attention to their investment decisions.

5.3.3. Exercise for entertainment

Various extant studies (Barber & Odean, 2000, 2001; Barber, Odean, et al., 2009; Grinblatt & Keloharju, 2001) contend that some investors may trade for reasons other than maximizing their investment returns, such as for entertainment. We acknowledge that "sensation seeking" may be one explanation behind why Chinese investors participate in the newly founded warrants market in general. However, it is not clear whether there is a direct link between "sensation seeking" and the reason that investors mistakenly exercise or fail to exercise warrants. Previous studies argue that "sensation seeking" may induce less sophisticated investors to trade excessively and underperform the proper benchmark. Following this logic, we would expect turnover and underperformance for these investors with irrational exercise

[21]When calibrating the regression model, we delete two observations that have extremely long exercise period (more than 40 days), considering the exercise period of the rest observations are all less than 15 days.

behavior to be significantly higher than those for investors who never exhibit irrational exercise behavior.

However, our further analysis based on the individual-level trading data does not provide support for such a conjecture. The average daily turnover is 5.71% for investors with irrational exercise behavior and 4.44% for investors without irrational exercise behavior. As for the abnormal return over the market index, the average daily abnormal return is -0.113% for investors with irrational exercise behavior and -0.108% for investors without irrational exercise behavior. The differences are not statistically significant in either case.

Barber and Odean (2000, 2001) argue that some investors may set aside a small percentage of wealth with which they trade for entertainment, while investing most of their wealth more prudently. Following this logic, it is also possible that some warrant holders irrationally exercise or fail to exercise a few shares of warrants for entertainment or sensation seeking and give up small profits and at the same time, rationally exercise the majority of their warrant holdings.

We indeed find some anecdotal support for such an argument. For example, there is an investor who held 5,000 shares of Wu-Steel's call warrant (ticker name 580013.SH) that should not be exercised. The investor rationally left 4,999 shares unexercised, while irrationally exercised one share. In another example, an investor exercised 26,195 shares of Ma-Steel's call warrant (ticker name 580010.SH) that should have been exercised and failed to exercise the remaining five shares. Such anecdotes suggest that the number (fraction) of irrationally exercised warrant shares, as used in the current study, instead of the number of people who made irrational exercises, is probably a more appropriate measure for investors' irrational exercise behavior.

5.3.4. Liquidity constraints

Because there is no practice of short sales in the Chinese stock market, it is possible that some investors holding an in-the-money warrant may be subject to liquidity shortage and do not own enough money to exercise a call warrant or own enough shares to exercise a put warrant. To investigate if liquidity shortage is an important determinant of the irrational behavior of "failure to exercise," we explore the individual-level trading data set to see how much money was needed to exercise those warrant contracts that should have been exercised but were not. Among all irrational exercises, we classify 518 observations into the category of "failure to exercise." Reviewing the summary statistics in Panel A of Table IX, we note that the average contract size that was irrationally unexercised is 2,150.4 shares (median is 110), and 75% of the contract size is no more than 800 shares. The average exercise notional value[22] is 10,563.87 Yuan (median is 782.5 Yuan), and 75% of the exercise volume is no greater than 3,800 Yuan. We also calculate the dollar Value of stock holdings and cash holdings for the same investors and present the results in Panel B and C of Table IX, respectively. Given the relatively large value of the stock portfolios and cash holdings, we do not feel that liquidity shortage plays a significant role in explaining the irrational behavior of "failure to exercise."

5.3.5. Other possible explanations

We have shown in Section 5.3.2 that investors are ignorant of warrant exercise mechanics and more information leads to better decision making. However, if information gathering is too

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[22]The exercise value is equal to the product of the number of shares of warrant, the exercise price, and the warrant's conversion ratio.

TABLE IX
Holding Profile for Investors with Irrational Exercise Behavior

	Mean	Q1	Median	Q3
Panel A. Warrant holding profile				
Contract size (shares)	2,150.40	11.00	110.00	800.00
Exercise value (Yuan)	10,563.87	133.00	782.50	3,800.00
Panel B. Stock holding profile (Yuan)				
Portfolio amount at warrant expiration	84,038.27	15,508.37	34,496.65	88,037.65
Portfolio amount at the end of 2006	72,842.92	6,210.81	18,159.22	55,320.03
Portfolio amount at the end of 2007	131,619.01	9,163.56	40,194.00	137,453.42
Portfolio amount at the end of 2008	54,470.28	2,903.78	14,517.11	48,860.79
Portfolio amount at the end of June 2009	118,944.40	4,486.32	27,586.94	90,265.73
Panel C. Cash holding profile (Yuan)				
Cash amount at the end of 2006	13,259.73	160.00	561.59	2,970.79
Cash amount at the end of 2007	38,165.94	214.91	921.86	8,067.30
Cash Amount at the end of 2008	13,523.17	92.08	507.13	3,741.84
Cash amount at the end of June 2009	10,707.03	149.23	713.14	5,250.04

Note. This table summarizes the holding profile for investors with irrational behavior of failure to exercise. Contract size of warrant holding is defined as the total shares of warrants that were irrationally unexercised. Exercise value is calculated as the sum product of the total shares of warrants that were irrationally unexercised, the strike prices, and the corresponding conversion ratios. Value of stock holding at warrant expiration is calculated as the sum product of the total shares of stocks hold and the corresponding stock prices.

costly, then failing to exercise valuable warrants may be a rational decision. In China, investors can easily and freely access information regarding the valuation and expiration of warrant contracts from a variety of sources.[23] So information gathering is not costly and could not be an important factor in the decision of warrant exercise.

Another possible explanation for the irrational behavior of failure to exercise is the dilution effect. The exercise of warrants can lead to an increase in the number of shares outstanding, which has the potential to decrease the underlying stock prices. However the possible dilution cannot impact our results and conclusions since the Chinese stock market follows the "T + 1" rule and there is a 10% limit on daily stock price change. We have considered the impact of the "T + 1" rule and potential price decrease in underlying stocks on the warrant exercise decision.

6. CONCLUSION

The current study examines the incidence and frequency of warrant holders irrationally exercising or failing to exercise their warrant contracts in the Chinese warrants market. We identified two types of irrational exercise behavior—"faulty exercise" and "failure to exercise"—without invoking any model of market equilibrium or model-dependent exercise criterion. Using a market-level exercise data set and an individual-level trading data set during the period of August 2006 through June 2009, we find that 121.64 million out of 19,002.12 million shares of warrants were irrationally exercised or unexercised. Such irrational exercise decisions have

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[23]Sources of such information include: websites of the exchanges and brokerage firms, major portal websites (yahoo, sina, etc.), major newspapers (China Securities News, Shanghai Securities News, Securities Times, etc.), and so on.

caused warrant holders to lose over 717.79 million Yuan over the sample period, out of which 712.32 million Yuan was lost because of failure to exercise warrants that were intrinsically valuable, and the remaining 5.47 million Yuan was lost due to faulty exercise of warrants that should not have been exercised.

The "T + 1" trading rule practiced in the Chinese stock market can partly explain the "failure to exercise" behavior. In addition, we believe that a substantial portion of the irrational exercise behavior and wealth loss can be attributed to warrant holders' ignorance of warrant mechanics and negligence. The frequency of irrational exercise for warrants listed at the Shenzhen Stock Exchange, which requires warrant issuers to post-notice and guidance of warrant exercise more frequently and with greater detail, is considerably lower than that for warrants listed at the Shanghai Stock Exchange. Moreover, warrants with a shorter exercise period experienced significantly higher frequency of irrational exercise than those with a longer exercise period.

The current study provides new insights into why some investors fail to rationally exercise their warrants. Future studies that attempt to gain more precise understanding of the reasons behind such irrational exercise behavior are needed to better understand investor behavior, option exercise behavior, and their implications to asset prices and corporate financial decision makings.

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