Front. Bus. Res. China 2015, 9(2): 243–267
DOI 10.3868/s070-004-015-0011-5

CASE STUDY

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The Chinese Stock Markets on Trial: The Fat Finger Accident of Everbright Securities

Abstract Everbright Securities Ltd. erroneously submitted huge quantities of buy orders on SSE180 constituent stocks from 11:05 through 11:07 on 16 August 2013. This fat finger accident had a pronounced impact on the Chinese stock markets. This paper uses the accident to study market quality and investors' responses. We show that the Chinese stock markets were robust enough to stand the trial, exhibiting deep depths and strong resiliency. However, the markets performed poorly in terms of aggregating information because there were large price swings after the erroneous orders were executed. Moreover, investors quickly change their beliefs as to the reasons to the dramatic price jumps, consistent with information cascade theory.

Keywords Everbright fat finger accident, market efficiency, market quality, information cascade

1 Introduction

On 16 August 2013, 25 minutes before the morning trading session ended, major

Received January 25, 2015

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Chinese stock indices suddenly and dramatically jumped. As shown in Figure 1, the SSE180 index, the most closely monitored index of the Shanghai Stock Exchange, rose by 6.7% at 11:07. Then the index plunged quickly in the following 8 minutes before it rebounded towards the end of the morning trading session. The dramatic price jumps caught investors by great surprise, and caused large market swings. However, the index began a free fall when the market re-opened at 13:00.

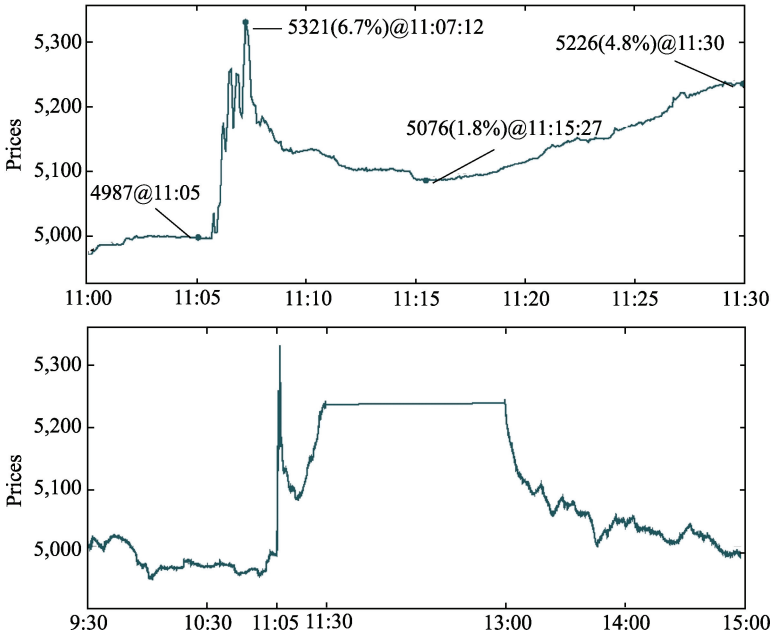

Figure 1 The Prices of SSE180 Index

The ups and downs of the prices were initiated by a flood of buy orders that Everbright Securities Co., Ltd (Everbright, hereafter) erroneously submitted due to a bug in its trading software. However, Everbright was not identified as the culprit until 13:00. In other words, the markets responded to the dramatic price jumps without knowing the cause in the last 25 minutes of the morning trading session. Moreover, Everbright's erroneous orders were 40 times larger than those the market normally handles. The quality of the Chinese stock markets was on trial that morning. This trial offers an excellent opportunity for us to examine how the Chinese markets work under extreme trading conditions, and how investors react to dramatic events within short periods of time. In this paper, we

use empirical evidence to address these issues.

We show mixed evidence on the quality of Chinese markets. On the positive side, despite the huge impact of the large quantities of orders, the market withstood the trial. The flood of orders quickly consumed the liquidity on limit order books, causing the market to fail to offer ask prices on several stocks for several seconds. But the quotes resumed very soon, and the bid-ask spreads recovered within several minutes. These results demonstrate the robustness of the Chinese markets, especially depth of market and strong market resiliency.

On the negative side, the Chinese stock markets performed poorly in terms of aggregating information and price discovery. The prices did drop immediately following the initial price jumps, but then prices rose again. Furthermore, the markets changed directions without any concrete information. These results illustrate the fragility of the Chinese markets.

The huge market swings in the morning reflected the sudden changes in investor beliefs, since the official announcement confirming Everbright's responsibility was not released until late afternoon. We find some traces of these belief changes in Weibo messages. Weibo is a very popular Chinese counterpart of Twitter. According to the Weibo messages before 11:15, investors on average believed the price jumps were due to market manipulation. After 11:15, some Weibo messages speculate that foreign institutional investors were heavily buying stocks. These messages coincided with the second market rise, implying that investors began to believe that there was unannounced good news.

We contribute to the market quality literature from a microstructure point of view. Market quality is the most important question in microstructure literature. Kyle (1985) first defines three dimensions of market quality: spread, depth, and resiliency. There have been many studies on spreads (e.g., Booth and Gurun, 2008; Ahn, Cai and Hamao and Ho, 2005; Huang and Stoll, 2001; Stoll, 2000). The main consensus from this line of studies is that spreads widens as the information asymmetry and information uncertainty become more severe, leading to poor market quality. Our results supplement this consensus by showing that extremely high information uncertainty can cause a failure of markets to provide valid spreads. The studies on depth and resiliency (Boulatov and George, 2013; Eom, Ok and Park, 2007; Foucault, Kadan and Kandel, 2005) are based on normal periods of time. By definition, market depth and resiliency should be measured following shocks. It is unclear whether the changes of depth

and spread in normal times can be really classified as shocks. In contrast, we study a shock of an extreme nature, which helps us better understand market resiliency.

We also contribute to information cascade theory, which was proposed first in economics and then applied in finance (Seiler, 2012; Cao, Han and Hirshleifer, 2011; Alevy, Haigh and List, 2007). However, the empirical evidence of information cascade in stock markets are scarce partly because investors' beliefs are unobserved. We address this difficulty by using Weibo messages, which are able to represent investors' perceptions with very high frequency. The sudden changes in investors' beliefs shown in this accident vividly signify how information cascade can affect the direction of stock markets without any warning. The only effective cure to the information cascade is to disclose authoritative information in time.

The remainder of this paper is organized as follows. Section 2 introduces the data we use. Section 3 reconstructs the accident. Section 4 and 5 examine the initial impacts and the spillover of the accident, respectively. The examinations of price swings and investors' beliefs are in Section 6. Section 7 discusses the policy implications of the accident. Section 8 offers our conclusions.

2 Data

Everbright's fat finger accident had a deep impact on Chinese stock markets. China Securities Regulatory Commission and the Shanghai Stock Exchange conducted detailed investigations of the accident. Based on the investigation reports, the regulatory rulings against Everbright, and Everbright's disclosures of the accident, we can accurately reconstruct the series of events that eventually led to the huge quantities of erroneous orders that were submitted and executed in the market.

We use high frequency trade and quote data to analyze the impact of the accident on the markets. The data are from Thomson Reuters Tick History. To process the high frequency trade, we follow Lee and Ready (1991). That is, if an order is executed at a price higher than the prevailing midpoint of bid and ask prices, this order is classified as a buyer-initiated order (a buy order, for short). Similarly, an order executed at a price lower than the midpoint price is classified as a seller-initiated order (a sell order, for short). The low frequency data, such as daily trading data and accounting data, are from the RESSET database.

In this paper, we examine how and why investors responded to the dramatic price jumps from 11:05 through 11:07. Finance theories suggest that investor beliefs are the key driving forces for their responses. Investor beliefs are, however, not directly observable. To investigate investor beliefs, we use Weibo data. Just like its counterpart Twitter in the U.S., anyone with access to the internet can register for a Weibo account and then publish his or her messages. All Weibo messages are publically available to all Weibo users. Weibo users often "friend" other Weibo accounts, so that they can instantly get updates from these friend accounts. Typically, a Weibo user does not need permission from another Weibo account to friend that account. Therefore, friending a Weibo account is similar to subscribing to a news feed. It is because of this feature that major news agencies and market commentators routinely use Weibo to report news and express opinions. Moreover, Weibo is far quicker than traditional newspapers, TV news, and news websites in reporting the latest news. This is because these traditional channels need go through a series of information processing procedures before they can publish a piece of news, whereas people can send out a Weibo message with just a few clicks. This paper studies the minute-by-minute responses of the markets, which provides a live broadcast of what investors were thinking, what rumors and speculations were circulating in the markets, etc. Clearly, the traditional channels are too slow to provide such a live broadcast. Altogether, Weibo messages best suit the purposes of this paper.

We collected Weibo messages as follows. Our initial search list started with the most popular financial Weibo list published on SINA.com.[1] We checked Weibo messages published from 11:05 through 15:00 on 16 August 2013, and collected the messages discussing the price jumps. Then we proceeded to check for the messages citing a Weibo not included in our initial search list. The cited Weibo was added to our search list. We repeated this process until we found the earliest and original Weibo messages related to Everbright's fat finger accident. Finally, we deleted the messages that weresimply forwarded and re-posted. Our final Weibo message sample consists of 359 messages, published by market commentators, news agencies, investors, and the Shanghai Stock Exchange. The first Weibo messages related to the accident appeared at 11:08. Between 11:08 and 11:15, there were 18 messages. Most of these messages just cited the

[1] Several major Chinese portal websites offer Weibo services. The SINA Weibo is the most influential.

dramatic price changes from 11:05 to 11:07. But one message alluded to the possibility of market manipulation. Another message speculated that foreign institutional investors were buying stocks heavily. Between 11:16 and 11:30, there were 30 messages, further speculating on the causes of the price jumps. The speculations included system failure of the Shanghai Stock Exchange and a fat finger accident by a major financial company (but not Everbright). During the stock market lunch break, there were 128 messages. The speculations further included various macroeconomic stimulus policies. A few messages during this period mentioned Everbright. However, these messages do not dominate the speculations. The rest of messages appeared in the afternoon trading session. More messages pointed to Everbright in the afternoon, although speculations on causes other than Everbright were still extant. The speculations finally ended when the official announcement of the true cause to the accident was released at 14:22.

3 The Course of the Everbright Fat Finger Accident

In the morning of 16 August 2013, the proprietary traders at Everbright Securities found price discrepancies between 180ETF, an index fund against Shanghai Stock Exchange 180 index (SSE180 index) and its underlying stocks. The SSE180 index consists of 180 large cap stocks listed on the Shanghai Stock Exchange, of which 8 stocks were suspended from trading that morning. Moreover, Everbright Securities is prohibited from trading its own stock, which is also a constituent of the SSE180 Index. Therefore, Everbright's traders were able to exploit the arbitrage opportunities by simultaneously trading 180ETF and the 171 constituent stocks of the SSE180 index that morning. With the help of an algorithm trading computer, the traders could place a group of orders with one click, and each group consisted of 171 orders to buy the 171 stocks. At 11:05:08, the traders found that among the previous group of orders, the orders for 27 stocks were unfilled. Hence, they proceeded to place buy orders for these 27 stocks. However, a bug in the algorithm trading software erroneously placed 27 groups of orders. That is, instead of buying the 27 stocks, they bought the 171 stocks 27 times. When the orders were submitted to the market, the Shanghai Stock Exchange quickly noticed the abnormal order flows and tracked down the source of the orders. One Exchange official called Everbright at 11:07, to inquire about trading purposes. Everbright's traders did not realize the mistakes they had

made until the Exchange official called. Immediately, the traders begun to cancel the unfilled orders. However, from 11:05 through 11:07, Everbright had submitted orders worth RMB 23.4 billion yuan, of which 7.27 billion yuan were executed.

When Everbright's huge number of buy orders came to the market within such a short period of time, the SSE180 index jumped dramatically. Several of the largest stocks even hit the upper limits. However, no one knew what had happened except Everbright's traders and a handful of Exchange and regulatory officials. Investors kept guessing as to the reasons for the sudden jump. According to the SINA Weibo messages we have collected, no finger was pointed at Everbright until the morning trading session closed. In response to a few speculations that Everbright's erroneous orders were responsible for the market jump, Mr. Jian Mei, Everbright's Board Secretary, publicly denied these speculations. Mr. Jian's denial failed to dispel speculation. Everbright was named the culprit more often. However, there were other speculations. The accusations against Everbright was far from concrete at that time. The afternoon trading session began at 13:00, when Everbright's stock was unexpectedly suspended from trading. The suspension, coupled with the speculations against Everbright, clearly sent a signal to investors. At 14:22, Everbright finally issued an announcement, taking full responsibility for the market jump in the morning.

This paper examines how the Chinese markets responded to the dramatic price jumps when there was no information on the reasons for the jump whatsoever. Therefore, we should look at the market responses from 11:05 through 11:30, as there were definite ideas as to the culprit for the accident prior to the market re-opening at 13:00. To validate there was no concrete information on the culprit before the morning trading session ended at 11:30, we plot in Figure 2 the prices of two "Everbright" stocks: Everbright Securities, listed on the Shanghai Stock Exchange, and China Everbright Ltd, listed on the Hong Kong Stock Exchange. Both firms belong to the Everbright Group Ltd.

While the stock of Everbright Securities stopped trading at 11:30 due to the lunch break at the Shanghai market, the stock of China Everbright Ltd continued to trade until the lunch break at the Hong Kong market starting at 12:00. Both the Shanghai and Hong Kong markets re-opened their afternoon trading session at 13:00. Comparing the afternoon prices of China Everbright Ltd shown in Figure 2 with the prices of the indices shown in Figure 1, we can see that China

Everbright Ltd's price dynamics are very similar to those of the indices. This similarity is because investors became aware that China Everbright Ltd's sibling firm was responsible for the accident and was very likely to experience losses and punishment in the near future. However, if we look at China Everbright Ltd's prices from 11:30 through 12:00, the prices went up dramatically. These rising prices strongly illustrate that investors did not consider Everbright to be the culprit at least until 12:00.

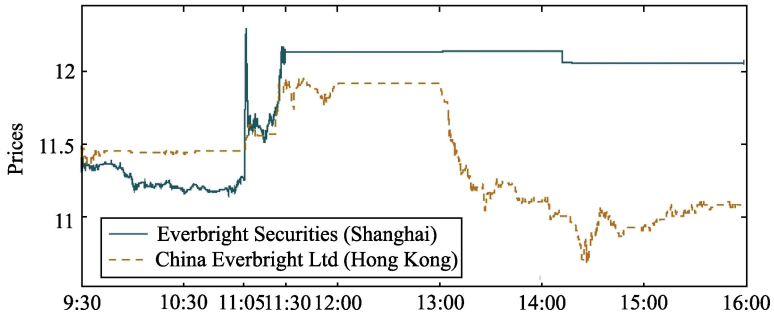

Figure 2 The Prices of Two "Everbright" Stocks

4 The Initial Impacts of the Everbright Fat Finger Accident

4.1 Recognizing Everbright's Erroneous Orders in Data

Within 3 minutes, from 11:05 to 11:07, Everbright bought 7.47 billion yuan worth of the 171 stocks. To put this into perspective, we summarize the 3-minute trading volume of the 171 stocks from 9:40 through 11:00. The mean and median are 186 and 156 million yuan, respectively. In words, the trading volume of the 171 stocks from 11:05 through 11:07 is about 40 times larger than in normal trading.

To verify the data, we calculate the "abnormal trading volume" for each of the 171 stocks for each minute from 11:05 through 11:07. The abnormal trading volume equals the stock's trading volume minus the mean (median) of per-minute trading from 9:40 through 11:00. The abnormal trading volume for the 171 stocks totaled 7.294 billion yuan, very close to the figure disclosed in the regulatory investigation report.

An interesting thing to look at is how Everbright's algorithm trading computer places orders. As Hendershott and Riordan (2013) and Hendershott and Riordan

(2013) have noticed, algorithmic trading has become very popular in the U.S. Markets. In contrast, very few researches have studied algorithmic trading in the Chinese markets, partly because of its slow development there. According to the media coverage following this accident, Everbright is one of the pioneers of algorithmic trading. The traders and their trading algorithm that were responsible for the accident were with the Strategic Trading Department, which focuses on various algorithmic trading strategies. Moreover, Dr. Jianbo Yang, the head of the Strategic Trading Department, is an expert on quantitative trading and was invited by the regulatory bodies to join in drafting a regulatory guideline on the trading of over-the-counter derivatives. Therefore, it is helpful to see how algorithmic trading works in practice in the Chinese markets.

Everbright's traders pressed one click on their computer and the algorithm generated 27 groups of orders. But the algorithm did not submit all the orders at once. Instead, it submitted them gradually. Based on the per-minute trading volume for each of the 171 stocks, we can find when the largest orders were submitted. We find that orders for 35 stocks were submitted within the minute of 11:05, 134 stocks were within 11:06, and 2 stocks were within 11:07. In addition, we also tested whether the size of the orders from 11:05 through 11:07 differ from those earlier that morning, and find no significant difference. In summary, the evidence shows that Everbright's trading algorithm followed well the textbook practices by gradually submitting and splitting large orders (e.g., Hendershott and Riordan, 2013; Khandani and Lo, 2011).

4.2 The Impacts on the Shanghai Stock Market

The previous subsection shows that Everbright's erroneous orders were both unexpected and large. These orders formed an extreme trial for the quality of the Shanghai stock market. To see the impacts of these orders, we randomly chose a stock from the 171 stocks and examined the changes of trading volume etc. We chose China Merchants Bank Co., Ltd (stock ID 600036).

Panel A of Figure 3 shows the order imbalances of the stock from 11:05 through 11:09. Order imbalances are the total number of shares of the buy orders minus that of the sell orders within each period of time between changes of quotes, usually lasting for 2 to 3 seconds. Most of the histograms in Panel A of Figure 3 are too small to be discernible, indicating that the buy and sell orders

were of similar size most of the time. There are, however, several exceptions. The largest order imbalance occurred at around 11:05:32, probably due to the first wave of Everbright's orders. Then two large buy orders followed at 11:06:09 and 11:06:51, respectively. Besides these three large surges of buy orders, there were a series of discernible buy orders from 11:05 through 11:07. This evidence reinforces the fact that Everbright's trading algorithm split the orders and gradually submitted them. What happened to the long histograms? In unreported results, we find that there were scores or even hundreds of orders coming to the market between changes of quotes. In normal times, there are typically only a few orders between changes of quotes.

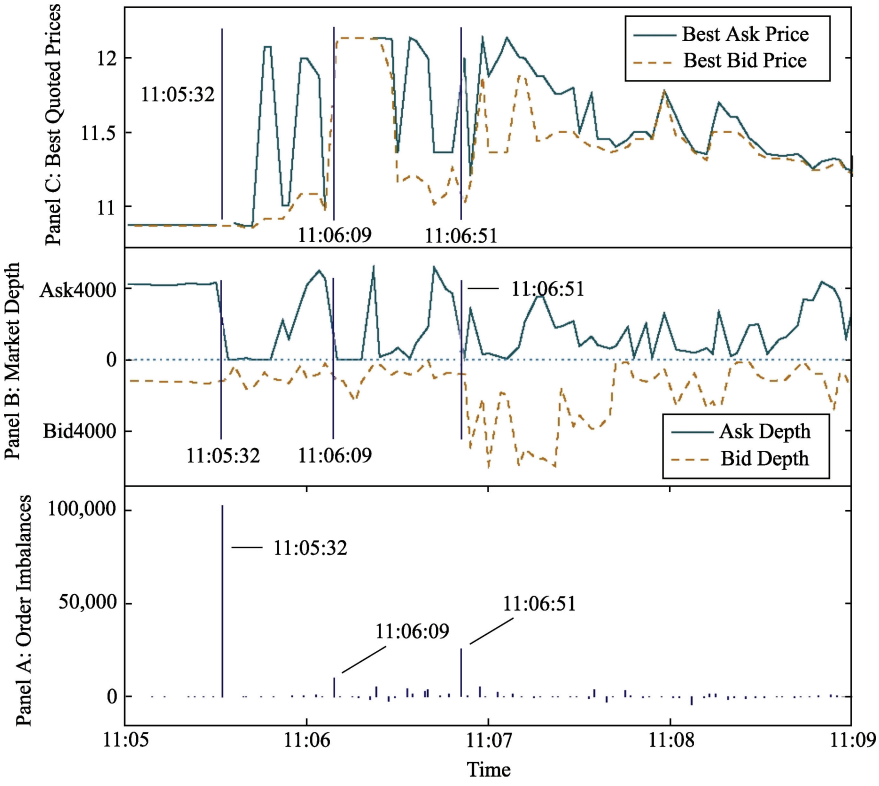

Figure 3 The Impacts of the Accident on One Stock

Panel B of Figure 3 shows the depths on both the buy and sell sides. The depths are defined as the quoted size of the best three quoted prices on each side. We add three vertical lines to Panel B in order to indicate the time when large

buy orders came to the market. At 11:05:32, when the largest chunk of buy orders were executed, the ask depth literally dropped to zero, though the bid depth remained relative stable. With the other two large chunks of buy orders, it was almost the same. Following the first two chunks of large orders, the ask depths remained zero for a few seconds, meaning that the quotations temporarily collapsed. Quotation failure was the first damage that Everbright's erroneous orders inflicted on the Shanghai stock market because no buy orders could be executed during the quotation failure. Why did the quotations fail? It was because Everbright's orders were so large, they were executed against every limit orders on the limit order book. In unreported results, the execution prices of these orders climbed. When we look at the data, it consists of a very long list of executions with rising execution prices, since Everbright split the orders into many small ones. To save space, we do not report the execution lists. However, we should keep in mind that all these transactions occurred within several seconds, much shorter than the time it takes to read the data. When Everbright's orders consumed all limit sell orders, there was no quoted ask price at all, therefore no ask price.

Panel C of Figure 3 reveals the second damage Everbright's orders caused the market, i.e., wide bid-ask spreads. Before 11:05:32, the best bid and ask prices were very close, which implies a narrow spread, typically 0.01 or 0.02 yuan. At 11:05:32, the solid line broke for several seconds because the ask prices were non-exist during that period of time. The best ask price resumed later on but with great fluctuations. At 11:06:09, when the second largest chunk of order hit the market, the ask prices disappeared again. This time the non-existence of ask prices lasted for a longer time. The fluctuations of ask prices continued until 11:08 when the best bid and ask prices converged and the spreads finally stabilized, albeit with wider spreads.

The above example is from one of the 171 stocks. However, all the 171 stocks had gone through the same trial. Figure 4 shows the average bid-ask spreads of the 171 stocks from 11:05 through 11:10. The spreads widened dramatically after 11:05, and then began to narrow around 11:08.

4.3 Market Quality in Terms of Spreads, Depth, and Resiliency

Clearly, Everbright's orders created a severe trial for the Shanghai stock market. This accident provides an opportunity for us to examine market quality in

practice. Regulators often ask and even organize brokers and exchanges to perform "stress tests" in order to check market quality. However, these tests are not real. The Everbright accident provided a real test on the market. Prior literature has proposed several dimensions to market quality, such as market depths, bid-ask spreads, and market resiliency (e.g., Kyle, 1985; Foucault, Kadan and Kandel, 2005; Large, 2007).

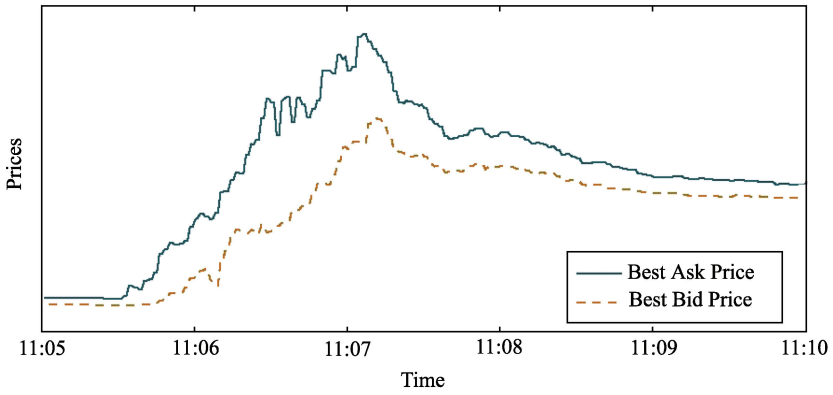

Figure 4 The Average Bid-Ask Spreads of the 171 Stocks from 11:05 through 11:10

In terms of market depths, the market performs well if, despite orders that are a dozen times larger than usual, the market can accommodate the orders. Even though in this case the ask side of the limit order book was empty for a few seconds, investors quickly filled the void by submitting new limit orders.

Market resiliency refers to the quality that "prices recover quickly after liquidity demand shocks" (Foucault, Kadan and Kandel, 2005, p. 1172). Obviously, the spreads widened dramatically when the large orders came in. But then, how long did it take for spreads to revert to their normal levels? We define the revision to normal spreads as follows. First, we calculate the means and standard deviations of spreads for each of the 171 stocks from 9:40 through 11:00. Second, we calculate the time weighted average spreads for each of the 171 stocks within each minute from 11:05 through 11:30. Third, we calculate the increases in spreads as the difference between the time weighted average spreads and the mean spreads during normal times. Fourth, we define the threshold for the increase in spreads to be significant. In the spirit of *T*-test, a natural threshold is three times the standard deviations of normal time spreads. However, spreads are not continuous. They are integer times of 0.01RMB, the smallest tick size in

the Chinese stock markets. Therefore, the above threshold is too stringent in the cases where the threshold is smaller than 0.01 RMB. To avoid this problem, we set the threshold of significant spread increases as three times the standard deviations of the spreads or 0.01 RMB, whichever is larger. Last, we deem the spreads as having reverted to their normal levels if the increases in spreads are not larger than the threshold during two consecutive seconds.

Table 1 Time for the Price to Recover

# of Minutes for Prices to Recover	# of the Stocks	% of the Stocks
1	1	0.59%
2	13	7.65%
3	22	12.94%
4	51	29.41%
5	35	20.59%
6	23	13.53%
7	11	6.47%
8	9	5.29%
9	3	1.76%
10	2	1.18%
11	1	0.59%

Table 1 shows that most of the stocks' spreads recovered from the shocks of the large orders within 7 minutes. Considering the huge quantity of orders that hit the market, 7 minutes can be deemed as a good performance in terms of market resiliency.

5 The Spillover of the Everbright Fat Finger Accident

5.1 The Immediate Spillover Effect

To evaluate whether the buy orders changed significantly, we do the following. First, we find the buy order size, in terms of number of shares executed, within each minute or each three-minute period for each stock in the morning. Because we do not know the distribution of order size, we bootstrap order size from 9:40 through 11:00 to find the empirical distributions of normal time buy order sizes, based on which we can test whether the buy orders significantly changed from

11:05 through 11:07. We apply the bootstrap on each stock for 1000 times. Last, if the buy orders from 11:05 through 11:07 lie within the 1% and 99% tails of the distribution, then we classify the buy orders as significantly decreased and increased, respectively. Otherwise, the changes are insignificant.

Table 2 reports the results. In the Shanghai market, very few stocks had a significant increase in buy orders at 11:05, consistent with our finding that Everbright split their orders and most orders were placed at 11:06 and 11:07. At 11:06 and 11:07, there were 195 and 303 stocks, 26.79% and 41.62% of all stocks listed in the Shanghai market, that experience significant increases in buy orders. Notice that Everbright's orders directly affected the 171 stocks. Therefore, this result implies that the impact spilled over to other stocks at once. The Shenzhen market, which was not directly affected by Everbright's orders, also experienced spillover from the event. There are hundreds of stocks that had significantly more buy orders from 11:05 through 11:07. Table 2 also shows that virtually none of stocks experienced a decrease in buy orders during that period of time. Altogether, the results demonstrate that investors were extremely quick to respond to the abnormal jumps of the 171 stocks. Furthermore, their response was to lean towards the wind by placing buy orders as quickly as they could.

Table 2 Changes in Buy Orders from 11:05 through 11:07

Market	Time	Significant Increase		Significant Decrease	Insignificant Change
		%	#		
Shanghai	11:05	2.06%	15	0.27%	97.67%
	11:06	26.79%	195	0.00%	73.21%
	11:07	41.62%	303	0.14%	58.24%
	11:05–11:07	46.02%	335	0.27%	53.71%
Shenzhen	11:05	2.42%	35	0.55%	97.03%
	11:06	18.23%	264	0.07%	81.70%
	11:07	31.22%	452	0.21%	68.57%
	11:05–11:07	34.88%	505	0.28%	64.84%

5.2 Why Were only Some Stocks Affected from 11:05 through 11:07?

Because we look at the spillovers during a very short period of time, there was not much time during which investors could figure out what had happened. Although it is quite obvious with hindsight that SSE180 constituent stocks were

facing strong buy orders, it was certainly a challenge for investors to figure out what had happened during those few minutes. Therefore, they might have to rely on the most high profile events as their benchmark to infer what was happening. According to the Weibo messages, investors were shocked by the sudden price spikes for several stocks, including the largest two Chinese oil companies, the five largest Chinese commercial banks, etc. Because of these names, investors might see two patterns: 1) Large firms, 2) Financial firms. The stocks of several of the largest firms in China hit upper price limits. In addition, the SSE180 index consists of the leading, very often largest, firms in their industries.

To examine whether blue ribbon firms and financial firms were affected by the accident, we regress both buy and sell orders on the indicators of blue ribbon stocks and financial stocks, as well as on several controls. The dependent variables are the natural logarithm of total buy and sell order volumes of each stock from 11:05 through 11:07. We use three proxies for blue ribbon stocks, i.e., firm size, a dummy of SSE180 constituent stocks, and a dummy of CSI300 constituent stocks. We measure the firm size by the natural logarithm of a firm's market capitalization. Both dummies of SSE180 and CSI 300 constituent stocks are equal to 1 if the firm is included in the respective index, and is equal to 0 otherwise. The regression also includes a dummy of financial firms, which equals 1 if the firm is in the financial sector and equals 0 otherwise. If our analysis stands, the three proxies for blue ribbon stocks and the dummy of financial firms should be positively related to buy orders. We control for the orders on the opposite side and the lagged orders on both sides because the prior literature shows that orders are correlated on both sides, and are persistent over time.

Table 3 reports the regression results. Column 1 reports the regression of buy orders. It shows that after controlling for the interrelations and persistence of orders, there were significantly more buy orders for large firms, SSE180 and CSI300 constituent firms, and financial firms, consistent with the hypothesis that blue ribbon and financial stocks were affected. Column 2 reports the regression of sell orders, which show similar results as the buy orders.

5.3 The Long Term Spillover of Other Stocks

The impacts of the Everbright fat finger accident were not confined to the 171 stocks. Other stocks in both the Shanghai and Shenzhen markets were also

affected. Figure 5 depicts the performances of the SSE180 index, which was directly affected by the accident, and three other indices, the Shanghai Stock Exchange Composite Index (SSEC), the Shenzhen Stock Exchange Composite Index (SZSEC), and the CSI 300 Index (CSI300). The SSEC index includes all stocks listed on the Shanghai Stock Exchange. Hence, the 171 stocks are also included in the SSEC index. The SZSEC index includes all stocks listed on the Shenzhen Stock Exchange. Therefore the SZSEC index has nothing to do with the 171 stocks. The CSI300 index was initially jointly launched by both the Shanghai and Shenzhen Stock Exchanges, and is now managed by China Securities Index Co., Ltd. The CSI300 index includes the stocks of the largest 300 firms in the markets. Most of the 171 stocks are also included in CSI300 index.

Table 3 The Regressions on Bid and Ask Orders from 11:05 through 11:07

	Buy orders	Sell orders
	(1)	(2)
Intercept	3.58***	–1.53***
	(0.31)	(0.52)
Firm size	0.41***	0.22***
	(0.03)	(0.04)
SSE180 constituent	1.99***	0.12
	(0.08)	(0.14)
CSI300 constituent	0.29***	1.07***
	(0.07)	(0.12)
Financial firms	0.42***	0.34*
	(0.12)	(0.20)
Opposite orders	0.11***	0.28***
	(0.01)	(0.04)
Lag (buy orders)	0.21***	0.27***
	(0.02)	(0.03)
Lag (sell orders)	0.07***	0.29***
	(0.01)	(0.02)
R-squared	0.75	0.59
No. of obs.	1,994	1,994

Note. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

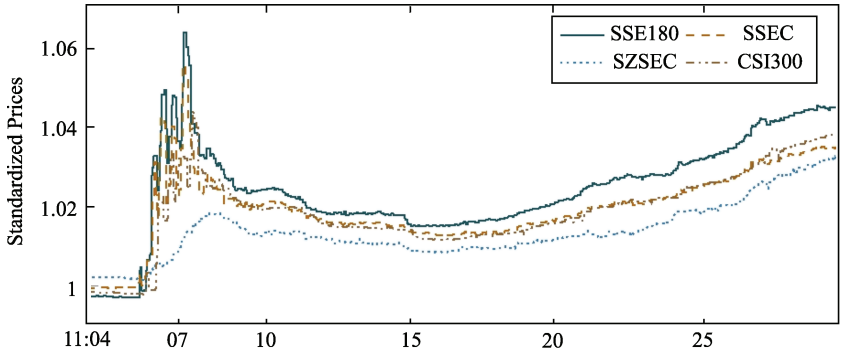

Figure 5 The Performance of Four Indices

Note: The four indices are the SSE180 (Shanghai Stock Exchange 180 Index), SSEC (Shanghai Stock Exchange Composite Index), SZSEC (Shenzhen Stock Exchange Composite Index), and the CSI 300 Index.

6 The Large Market Swings Following the Initial Impacts of the Accident

6.1 The Rise and Fall of the Market

As Figure 1 and Figure 5 show, both the Shanghai and Shenzhen markets experienced large swings after the initial shocks. The market went down rapidly from 11:08 through 11:15. Then in the last 15 minutes of the morning trading session, the market gradually yet steadily rose. These price fluctuations were echoed by the order imbalances shown in Figure 5, which aggregated the per-minute order imbalances of all SSE180 index constituent stocks from 11:05 through 11:29. From 11:08, sell orders began to dominate buy orders, immediately after Everbright's orders were stopped. The domination of sell orders lasted until 11:15. This result demonstrates that investors were suspicious about the huge jump. However, starting from 11:16, buy orders dominated sell orders, pushing the prices up again.

The order imbalances patterns shown in Figure 6 are supported by the following regressions. We augment the regressions in the previous section by regressing the orders from 11:05 through 11:29 and by adding time dummies to see the changes in orders within each three-minute period.

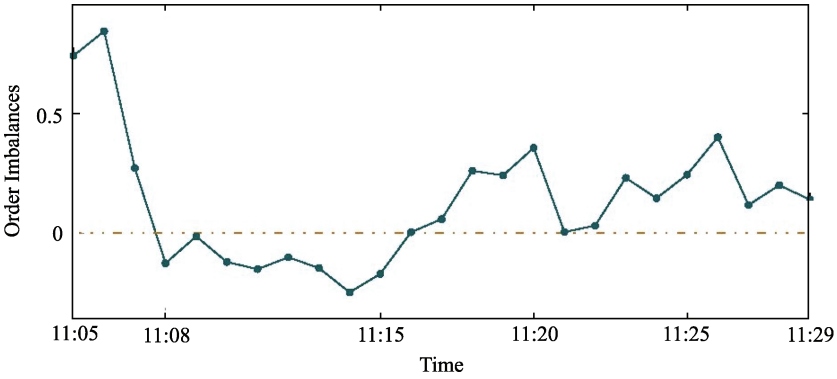

Figure 6 The Order Imbalances of the SSE180 Index from 11:05 through 11:29

The regressions in Columns 1 and 2 of Table 4 are applied on all orders. However, the orders from 11:05 through 11:07 may be too abnormal. Therefore, we exclude these orders from the regression samples in the regressions whose results are reported in Columns 3 and 4. We divide the time from 11:05 through 11:29 into eight time slots. Each of the first seven time slots lasts for three minutes. The eighth time slot is from 11:26 through 11:29, lasting for four minutes[2]. We use the eighth time slot as the benchmark time dummy. The regressions show that from 11:05 through 11:07, buy orders significantly increased. Later on, buy orders significantly started to drop from 11:08. The magnitude of the drop peaked around 11:14 to 11:16. After that, though buy orders were still less than those in the last time slot, buy orders began to increase again relative to the period from 11:08 to 11:16. Buy orders steadily increased towards the end of the morning trading session. Sell orders exhibited similar patterns. That is, there were more sell orders before 11:16, and fewer sell orders after 11:16. In summary, the markets experienced large swings after the initial shock. The large swing was because investors changed their minds around 11:14 to 11:16. As the previous sections show, there was no concrete information on why the prices suddenly and dramatically jumped from 11:05 through 11:07. Therefore, investors had to speculate on the reasons for the price jumps. Figure 6 and Table 4 illustrate that before 11:16, investors on average seemed to doubt that there was actual good news behind the price jumps. However, after 11:16, investors somehow came to think that the price jumps were indeed caused by genuine good news.

[2] The morning trading session ended at 11:30. Thus, the last trading minute is 11:29.

Table 4 The Regressions on Bid and Ask Orders from 11:05 through 11:29

	Buy orders	Sell orders	Buy orders	Sell orders
	(1)	(2)	(3)	(4)
Intercept	2.28 ***	0.73 *	2.09 ***	0.92 **
	(0.29)	(0.41)	(0.23)	(0.40)
11:05 through 11:07	0.76 ***	–0.38 ***		
	(0.02)	(0.03)		
11:08 through 11:10	–0.26 ***	0.21 ***	–0.29 ***	0.20 ***
	(0.03)	(0.02)	(0.03)	(0.02)
11:11 through 11:13	–1.40 ***	0.21 ***	–1.44 ***	0.16 ***
	(0.04)	(0.06)	(0.02)	(0.04)
11:14 through 11:16	–1.43 ***	0.16 **	–1.42 ***	0.12 *
	(0.02)	(0.07)	(0.03)	(0.07)
11:17 through 11:19	–0.84 ***	–0.23 ***	–0.81 ***	–0.25 ***
	(0.04)	(0.05)	(0.03)	(0.06)
11:20 through 11:22	–0.37 ***	–0.06 ***	–0.34 ***	–0.06 ***
	(0.03)	(0.02)	(0.02)	(0.02)
11:23 through 11:25	–0.32 ***	–0.09 ***	–0.31 ***	–0.09 ***
	(0.01)	(0.01)	(0.01)	(0.01)
Firm size	0.27 ***	0.14 ***	0.24 ***	0.13 ***
	(0.04)	(0.02)	(0.03)	(0.01)
SSE180 constituent	0.37	0.08	0.12	0.06
	(0.29)	(0.10)	(0.17)	(0.12)
CSI300 constituent	0.17 **	0.21	0.15 *	0.09
	(0.08)	(0.18)	(0.09)	(0.16)
Financial firms	0.50 ***	0.28 ***	0.48 ***	0.26 ***
	(0.08)	(0.06)	(0.08)	(0.07)
Opposite orders	0.22 ***	0.26 ***	0.21 ***	0.24 ***
	(0.03)	(0.03)	(0.03)	(0.03)
Lag (buy orders)	0.27 ***	0.20 ***	0.31 ***	0.21 ***
	(0.04)	(0.02)	(0.03)	(0.02)
Lag (sell orders)	0.09 ***	0.33 ***	0.12 ***	0.34 ***
	(0.03)	(0.04)	(0.03)	(0.04)
R-squared	0.64	0.58	0.61	0.58
No. of Obs.	16,746	16,746	14,752	14,752

6.2 What Caused the Fall and Rise of the Market?

The market experienced large swings following the initial shocks. We have shown that the swings were due to the changes in investors' beliefs. In this subsection, we use the Weibo data to reinforce this argument. If we look at the Weibo messages, we can see that during 11:08 to 11:16 there were several Weibo postings discussing the price jumps, of which three speculated on the reasons for the price jumps. The first speculation appeared at 11:10, saying that "...the price of the CSI300 Index Futures jumped by 54 points, which is definitely a manipulation of the market..." The second speculation, appeared at 11:12, attributing the price jumps to the same reason: a manipulation of CSI300 index prices in order to profit on CSI300 Index Futures. These two speculations, without hindsight, make perfect sense considering the facts that 1) that day was the delivery day of the CSI300 Index Futures, 2) huge price jumps have seldom been seen before. These two Weibomessages exhibit investors' general perceptions at that time, i.e., that the price jumps were due to market manipulations, and thus were bound to drop after the manipulators stopped.

At 11:14 the third Weibomessageappeared. This post did not clearly offer a reason for the price jumps but rather an observation that "...with the indices plunging, buy orders at low prices have begun to grow, indicating signs of bottom fishing... Seems like foreign institutions are madly buying ETFs." This post is likely to mark or reflect a turn in investors' beliefs, i.e., that there may be or was very likely to be some unannounced good news since some investors started to buy stocks very heavily.

The large swings in the market underscore the fragility of the stock markets. The markets change their directions without solid reasons. Notice that fragility is not only a characteristic of Chinese stock markets, but also that of western stock markets. Foucault, Kadan and Kandel (2005) examines the media news prior to major stock market crashes in the 20th century, and finds no material bad news that could explain the sudden collapse of both stock prices and investors' confidence in the markets. The large swings after Everbright's accident were very similar to the sudden market crashes described by Shiller (2005). There was no concrete or authoritative information on why the price jumped from 11:05 through 11:07. According to the Weibo messages, investors were eagerly looking for reasons for the price jumps, but all they could do was to speculate. It was in such an information environment that the market suddenly changed

direction.

How can a stock market be so fragile that it changes direction without a reason? Shiller (2005) argues that market fragility is due to information cascade. That is, when investors are facing high levels of uncertainty, a small event may trigger a sudden change in their beliefs. The information environment following Everbright's orders is consistent to the conditions for information cascade to occur. The dramatic price jumps from 11:05 through 11:07 made investors believe that if there was really some good news, the news would have huge impacts on the markets. Therefore, they felt it imperative to find out whether there was good news. Yet, there was virtually no clue. In this case, investors became extremely uncertain. Thus, the indication that some investors were buying stocks heavily could easily cause investors to abandon their suspicion of market manipulation, not on solid ground in the first place.

7 Policy Implications

There is no doubt that Everbright was the culprit of the accident. However, should Everbright take full blame? On the one hand, it was Everbright's erroneous orders that triggered the market turmoil on 16 August 2013. On the other hand, once Everbright's orders were stopped, the markets started cooling off and almost fully recovered within only 8 minutes. If the markets had continued to cool off until 11:30, the Everbright accident would have been nothing more than a market drama in which Everbright traded foolishly and was preyed upon heavily by others. In this hypothetical scenario, the Everbright accident would not have been an accident for the Chinese stock markets, but an accident for only Everbright itself. What escalated Everbright's foolish trading into market turmoil was the second market rise starting from 11:15. But this rise was hardly an inevitable consequence of the foolish trading. In stock markets, which are unexceptionally full of information asymmetry, foolish trading is by no means scarce. Therefore, it is unfair to put the blame squarely on Everbright.

We believe that the delayed information disclosure should take a large, if not the largest, part of the blame. Figure 1 and Figure 6 clearly indicate that markets were cooling off immediately after Everbright's erroneous orders stopped. The cooling off period lasted for around 8 minutes. This 8-minute period was an excellent window of opportunity to disclose information. Since it was the

officials at the Shanghai Stock Exchange, instead of the traders of Everbright, who first spotted the abnormal buy orders, the Exchange was fully aware of what had happened. Therefore, the regulators did have the capability to make a clarification announcement during that 8-minute window of opportunity.

Of course, the regulators did have some justifications for their slow response. First, it took time to find out every detail of what had happened. With hindsight, the cause to the accident is very obvious. But that morning, even Everbright's traders, who were best positioned torealize the cause, were in a panic. There were rumors that Everbright's traders, dumbfounded when they received the Exchange official's call at 11:07, had to unplug the computers that run the algorithmic trading program in order to prevent any further order submissions. These rumors may not be true. But they highlight the mental shocks that Everbright's traders were experiencing. These mental shocks made it impossible to quickly understand the details of what had gone wrong. Without knowing these details, it would be equally irresponsible to single out Everbright as the culprit. Secondly, what happened on 16 August 2013 was the first time that the Chinese markets encounter this type of accident on such a large scale. The lack of protocols for handling such accidents impeded the regulators' responses. Lastly, even though Everbright mistakenly submitted the orders, these orders were submitted and processed strictly following the Exchange's trading rules. From the legal point of view, there were nothing wrong with these orders. Neither did the regulators have any legal grounds to block the submission and execution of these orders. In summary, it would be neither technologically feasible nor legally justified for the regulators to announce Everbright as the culprit during the 8-minute window of opportunity when the detailed investigation into the accident was far from finished.

However, to mitigate the information uncertainty and avoid market swings, an announcement without naming a name might be appropriate. Specifically, based on the facts that the regulators had already gathered prior to the 8-minute window of opportunity, the regulators could had made an announcement stating that one trading desk had submitted a large quantity of buy orders from 11:05 through 11:07. An announcement as vague as this one could have given investors important hints of the causes for the price jumps from 11:05 through 11:07. To support this argument, we can look at the market prices in the afternoon of 16 August 2013. Figure 1 demonstrates that the markets plummeted immediately

when the afternoon trading session began at 13:00. Furthermore, within around 40 minutes, the prices dropped nearly to the pre-accident level. In other words, investors agreed in the afternoon that the initial price jumps in the morning were a mistake. But this price drop was not due to any authoritative announcement on the accident, because the first official announcement confirming Everbright's responsibility was not released until 14:22. According to the Weibo messages, investors were still debating whether the price jumps in the morning were due to pending stimulus macroeconomic policies. Everbright was indeed named in some Weibo messages, but these messages were not certain about Everbright's responsibility. Therefore, the evidence indicates that investors were smart enough to infer the true causes from slight hints.

8 Concluding Remarks

This paper studies the impacts of and market responses to Everbright's fat finger accident on 16 August 2013. We show mixed evidence on the quality of the Chinese stock markets. The markets withstood the trial caused by the huge flood of buy orders within a very short period of time. Although the market failed to offer quotes for several seconds, they began to function properly very quickly and the market was able to accommodate orders that were far larger than those it normally handles. However, the markets also exhibited poor performance in terms of aggregating information. There was no concrete information on the causes of the price jumps from 11:05 through 11:07. Investors had to speculate. The speculations were correct at first, but they took a wrong direction very soon. It is interesting to see that the markets were very fragile in that there were large swings and the swings were consistent with information cascade theory because investors were facing extremely high levels of uncertainty in the last 25 minutes of the morning trading session on 16 August 2013.

There have been heated debates on the accident. Several key figures involved in the accident have been penalized. An interesting sequel of this accident is that Dr. Jianbo Yang, the head of Everbright's Strategic Trading Department and the person penalized most due to the accident, sued the China Securities Regulatory Commission, arguing that he did the right thing when he found Everbright had placed incorrect orders. Some investors attempted to sue Everbright for manipulating the markets and causing these investors to mistakenly buy stocks.

The evidence shown in this paper sheds new light on these debates. The key problem may not be how Everbright should have properly reacted when it discovered the erroneous orders. The markets and investors would have been better off if the Shanghai Stock Exchange had disclosed the causes behind the dramatic price jumps earlier. This disclosure did not appear until late that afternoon. Should investors have known the causes earlier, the market could have performed in a more efficient way.

Acknowledgements We gratefully acknowledge the support by National Natural Science Foundation of China through grants 71202146 and 71402028. We thank the Executive Editor-in-Chief and two anonymous referees for helpful comments.

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