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Completed Research Paper

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Abstract

This research investigates information transmissions between stock returns and abnormal posting volumes using a total of 1,031,206 messages posted on Chinese stock message boards. Based on a multivariable GARCH (1, 1) model and causality in variance test, the study shows that there are significant two-way volatility spillovers effects: a positive volatility spillover effect from stock returns to abnormal posting volume, and a negative volatility spillover effect from abnormal posting volume to stock returns. The information exchange and communication on stock message boards have a certain role to stabilize financial markets and to improve the investment rationale.

Keywords: information transmission, volatility, stock returns, stock discussion boards

Introduction

Stock message boards are online discussion boards or forums where individuals share and exchange information about stock and investment topics. Stock message forums can host hundreds to thousands of discussion boards on individuals stocks and facilitate discussions among individual investors. They allow investors to comment stocks; exchange information; and interact socially (Das et al. 2005). Popular Stock message boards include Yahoo Finance, Google Finance, SiliconInvestor.com, RagingBull.com, and others. Stock message boards provide an excellent platform for investors to interact, debate, and exchange stock information. Information posted on stock message boards influence individual investors attitudes and decisions, and therefore influences their behaviors in stock markets.

Recently, there has been increasing interest in the roles that Stock message boards play in financial markets and personal finance. The Internet helps investors learn a wide range of financial information from stock prices, trading volume, to quarterly or yearly reports. Questions are raised about whether online posting messages help predict changes in stock market returns and volatility (Black 1986; Wysocki 1999).

Previous extant studies have evaluated the relationships between online stock discussion boards and stock returns and trading volume. For example, Wysocki (1999) examined messages-posting volume on Yahoo! Message boards and found that overnight message-posting volume could predict changes trading volume and returns on t+1. Firms with high cumulative posting volumes were characterized by high short-seller activities, high trading volume, low institutional holdings, extreme performance, and high analyst followings. Tumarkin and Whitelaw (2001) examined the messages posted on RagingBull.com and they found that changes in investors' opinions on days with abnormally high message activities were correlated with abnormal industry-adjusted returns. However, they found that the message board activities did not predict returns and trading volume. Antweiler and Frank (2004) also analyzed the messages posted on Yahoo! Finance and RagingBull.com and they found that the stock messages could help predict market volatility, but not stock returns.

Other studies have explored whether postings on discussion forums were valuable to assist investors make investment decisions. Bagnoli et al. (1999) compared the First Call analyst earning forecasts to unofficial "whispers" online forecasts. They found that the whispers tended to be more accurate on corporate earnings announcements. Dewally (2003) investigated the value contained in stock recommendations posted on two Internet news groups. His results showed that the stocks recommended by posters were the ones performed well in recent market, but they did not earn any significant cumulative abnormal return over the next 5, 10, and 20 trading days.

Most of extant studies lay emphasis on the applications of stock message board activities to forecast stock market performance from a practical perspective. Researchers employ the stock message board variables (messages posting volume and investors' opinions) to study how these variables impacted the market variables (trading volume, stock returns, variance, and volatility). However, these studies generally ignore the influence of discussion board messages of outside market information on the variation of stock markets. These studies did not use more suitable econometrics models even though financial time series, such as stock prices, often exhibit the phenomenon of volatility clustering. Besides, prior research usually examines the information transmission direction from message boards to stock markets, but not the two-way information transmission between stock markets and stock message boards.

The purpose of this study is to investigate the two inverse information transmissions between stock markets and stock discussion boards. Specifically, this study is to examine whether there is information transmission: from the stock market to "after-hour" activities on discussion forums, and also from "after-hour" activities on discussion boards to the stock market on t+1.

Such inquiry makes several important contributions. First, information is the core piece to determine a stock price according to finance theory. New information is a fundamental cause to influence the changing of a stock price. To have a better understanding of the relationship between information and stock markets, we need to conduct research from an information transmission perspective. This study explores the information transmission from both directions between stock markets and stock message boards. The volatility of stock returns will affect the investor's participation of the message postings. In turn, the investors who obtain the information from the message postings

will reflect their behaviors in the stock market. Such approach provides us a more comprehensive picture of information exchanges inside and outside stock markets.

Secondly, a GARCH mode is used in the present paper to capture the phenomenon of volatility clustering and estimate the conditional volatilities of stock returns and message posting volume. Financial data suggests that some time periods are riskier than others, and these periods scatter randomly across the data set. In addition, there is autocorrelation in the riskiness of financial returns. Financial analysts notice that there are clearly periods of small fluctuations and periods of large fluctuations and describe this as "volatility clustering." Generalized autoregressive conditional heteroskedasticity (GARCH) models are designed to accurately describe these issues. Multivariate linear models used in Wysock (1999), Tumarkin and Whitelaw (2001), and Antweiler and Frank (2004) assume that the expected value of all squared error terms is the same at any given point. For financial time series, however, variances of error terms are not equal, which is called heteroskedasticity. These models do not effectively provide a volatility measure in financial applications. GARCH models treat heteroskedasticity as a variance to be modeled. As a result, not only are the deficiencies of least squares corrected, but a prediction is computed for the variance of each error term.

Thirdly, previous literature mainly examined the relationship between stock markets and stock message boards using a sample of certain individual stocks. Based on the Granger causality test and the Cross-Correlation Function (CCF) causality-in-variance test, our study collects the market index and total number of message postings. This approach can avoid the individual stock different attributes, and then provides a holistic perspective for this research topic.

The rest of the paper is organized as follows. Section 2 provides literature review, and section 3 outlines the hypotheses development undertaken in the present paper. The background information on stock markets and online stock discussion forums in China, data source, construction of variables, and econometric methodology are described in section 4. In section 5, we discuss the empirical results. We conclude this study in section 6.

Literature review

Previous studies have evaluated the relationship between online stock discussion forums and stock returns and trading volume. We summarize their studies and findings below.

One of the first studies of Internet stock forums was conducted by Wysocki (1999). He analyzed the volume of postings on various Yahoo! message boards. For the 50 firms with the highest posting volume between January and August 1998, he found that message posting did forecast next-day trading volume and next-day abnormal stock returns. The firms with high message posting activity were characterized by high short seller activity, high market valuation relative to fundamentals, high trading volume, and high analyst following, but low institutional holdings.

Tumarkin and Whitelaw (2001) studied the messages posted on the RagingBull.com from mid-April 1999 to mid-February 2000 and they reported that on days with abnormally high message activities, changes in investors' opinions were correlated with abnormal industry-adjusted returns. However, they found that the message board activity did not predict industry-adjusted returns or abnormal trading volume. Antweiler and Frank (2004) also analyzed the messages posted on Yahoo! Finance and RagingBull.com and they found that the stock messages could help predict market volatility, but not stock returns.

Bagnoli et al. (1999) compared the First Call analyst earning forecasts to unofficial "whispers" forecasts. The whispers were collected various sources including Internet web pages and news stories. They found that the analysts from First Call tended to underestimate corporate earnings announcements, while the whispers tended to be more accurate. Their results also suggested that whisper information appeared to be widely enough disseminated so that at least part of this information is incorporated in stock prices prior to the earnings release.

Other studies explore whether postings on discussion forums are valuable to assist investors make investment decisions. Dewally (2003) investigated the value contained in stock recommendations posted on two Internet news groups. He found that the stocks recommended by posters were the ones performed well in recent market, but these stocks did not earn any significant cumulative abnormal return over the next 5, 10, and 20 trading days.

According to Samuelson (1965) and Mandelbrot (1966), if markets are working properly, all information regarding an asset will be channeled immediately into its price. To have a better understanding of the relationship between outside information and stock market performance, we need to conduct research from the perspective of information diffusion. Clarkson et al. (2006) examined the market reaction to takeover rumor postings in an Internet discussion forum. Results from the inter-day analysis showed abnormal returns and trading volumes on the day before and the day of the posting. Results of the intra-day analysis showed abnormal returns and trading volumes during the 10 min posting interval and abnormal trading volume during the 10 min interval immediately preceding it. In another study, Gu et al. (2006) found that informed investors existed in stock message boards, but their information is neither fully incorporated into the market price, nor fully acknowledged by peers in stock message boards.

Hypotheses Development

Individuals who have obtained information about the stock market activities may respond by analyzing and exchanging (posting) messages in some stock discussion forums. Their own opinions can be extended to the people who have reviewed message postings, including potential investors. Informative stock discussion forums also play the role as the transmission channel that discloses new information which is not directly shown by the stock markets. For example, some "insiders", such as experts in a company, might post messages that include private information (Tumarkin et al. 2001), which is not reflected by the performance of stocks. As a result, the information will be known by more investors and become no longer private. Most of investors are interested in knowing about what information other investors have obtained, and then they will be able to understand others' beliefs and actions and make their own investment decisions. Black (1986) pointed out that "noise" in financial markets is often so powerful that makes trading possible, and thus allows us to observe fluctuations of financial assets prices. Based on the discussion above, the first hypothesis is formally stated as:

H1: There is transmission of information between stock markets and stock discussion boards.

Both stock markets and stock discussion forums can transmit information to investors, but there is asymmetric information transmission between the informed and uninformed groups when there are public disclosures. All investors do not view stock discussion forums very often during the day and thus fail to obtain simultaneous information. Even greater asymmetry is created by the different abilities of investors to understand, analyze, and process the new information. In addition, analysts usually would like to disclose conclusions from stock market analyses after the exchange closes. Because of the existence of time asymmetry of information transmission, a great amount of information about the stock markets will be exchanged during after-trading hours. Then there is information transmission from stock markets to "after-trading-hours" or "after-hours" stock discussion forums. This phenomenon is even more remarkable than the information transmission from stock markets to "trading-hours" discussion activities. Our second hypothesis posits:

H2: There is transmission of information from stock markets to "after-trading-hours" stock discussion boards.

Stock discussion forums provide investors opportunities to deliver valuation-relevant information and/or their own opinions to greater public. A large number of investors may follow the buy and sell recommendations of message board posters. They make their investment decisions based on these opinions such that the information is also transmitted to the stock markets. This is the so-called "herd behavior" (Scharfstein et al. 1990). Investors simply follow and mimic other investors' decisions. Our third hypothesis is stated as:

H3: There is transmission of information from "after-trading-hours" stock discussion boards to stock markets.

Data and Methodology

Data

There are three stock exchanges operating independently in the People's Republic of China: the Shanghai Stock Exchange, the Shenzhen Stock Exchange, and the Hong Kong Stock Exchange. The current Shanghai Stock Exchange (SSE) was established and in operation in 1990. As the most preeminent stock market in Mainland China, the SSE had over 71.30 million investors and 860 listed companies at the end of 2007. Stock discussion forums have

arisen along with the fast development of stock markets in China. They have experienced from bulletin boards to interactive discussion communities, and to the current specific stock discussion forums.

We selected the stock discussion boards from Sina.com, the most popular and consistent stock discussion site in China, because it can provide the largest sets of message boards and the highest number of page views, and then we can construct an accurate measure of posting volume on a daily basis. In addition, Sina.com has a message board for each stock, which matches our need of collecting general information about stock returns. Our focus is on the Shanghai Stock Exchange (SSE), the most prominent stock exchange in China, for the purpose of collecting systematic and consistent data for stock market returns.

Data on discussion boards were collected from November 16, 2007 to April 10, 2009, a total number of 341 trading days for SSE, which include weekdays except for designated holidays. November 16, 2007 is the earliest available archive date in the discussion boards, and April 10, 2009 is the date of data collection for this study. A total of 1,031,206 messages posted on the Sina.com was downloaded. The research periods for message postings are 3:00 pm after exchange closes each day to 9:30 am on t+1. We chose to focus on new message postings but not subsequent replies because the latter often degenerate into "trash talk" with only limited connection to stocks. Data on stock prices, earnings, and market returns were collected from the China Stock Market & Accounting Research (CSMAR) database.

Data analysis method

Most of the prior research ignores the fact that financial time series, such as stock prices, often exhibit the phenomenon of volatility clustering so that they did not use econometrics models that are more suitable for these financial time series, such as ARCH or GARCH models. For example, Wysocki (1999) examined the stock message posting volume, next-day trading volume, and next-day abnormal stock returns. Tumarkin and Whitelaw (2001) assigned different scales to measure the effect of positive or negative pinions on each message board. Dewally (2003) studied the value contained in stock recommendation postings.

Our study is based on the Granger causality test and the Cross-Correlation Function (CCF) causality-in-variance test. We add to the literature by building up a GARCH (1, 1) model, which can well capture the phenomenon of volatility clustering to estimate the conditional volatilities of stock returns and abnormal message posting volume. The present research is also the first to provide systematic evidence on the relationship between variation in stock message posting volume and changes in stock returns for the emerging financial market of China. Considering the time asymmetry between message posting periods and stock market trading hours, we divide the time series into trading and after-trading hours and intend to examine the relationship between message posting volume and stock market performance given the direction of information flow.

Construction of variables

Stock discussion forums are available to the investors without time limit even though trading hours for SSE are from 9:30 am to 3:00 pm, excluding the lunch break between 11:30 am and 1:00 pm. Figure 1 provides a histogram illustrating the distribution of message posting volumes per day. The distribution is skewed to the left, and there is wide variation in the posting volume within a day. Message posting activity is consistently high when the stock exchange closes, which are after-trading hours.

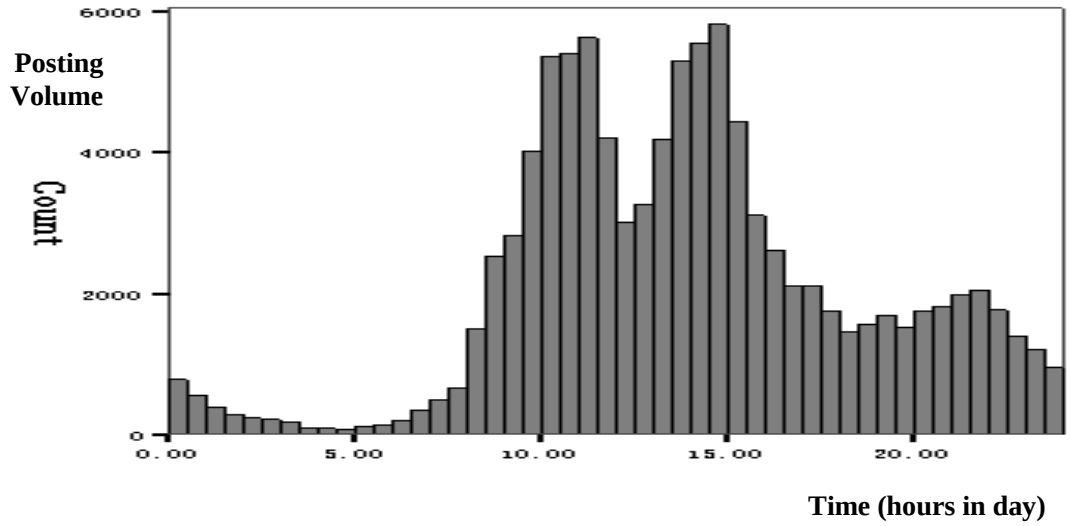

Figure 1: Intraday Message Posting Volume

Because of this time asymmetry, we would like to divide the time periods of message postings into two categories, trading and after-trading hours, to better capture the flow of information between stock markets and stock discussion forums. Our research studies three time series to investigate the relationship between variation in posting volumes and changes in stock performance. Let r_t denote the conditional volatility of stock return, Ps_{t^*} be the conditional volatility of message posting volumes during after-trading hours, and Eps_{t^*} be the conditional volatility of abnormal message posting volumes during after-trading hours. Abnormal message posting volumes include those that are at least two standard deviations away from the five-day moving average number of message postings. We would like to explore the effect of phenomenal activities in stock discussion forums. Details of the division of the time periods are shown in figure 2.

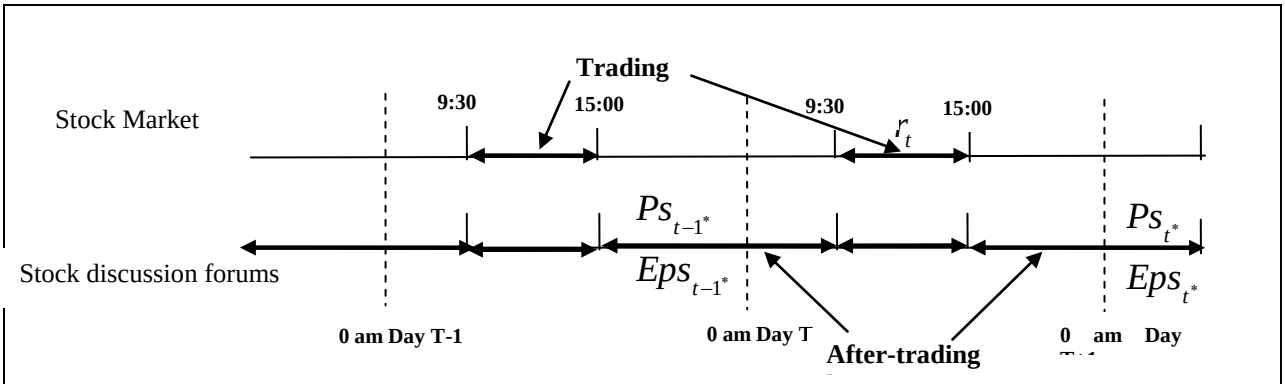

Figure 2: Different Time Periods

(1) Conditional volatility of stock returns

Different from Wysocki (1999), we chose the stock return conditional volatility as the time series to measure changes in stock returns and reaction to the messages posted by market participants. The conditional volatility is allowed to depend on the available data while also evolve with time. It is of more practical interest to us than the volatility of the time series considered as a whole to examine whether daily changes in posting volume is correlated with daily changes in stock returns. The most popular approach to estimate conditional volatility is the GARCH model (Bollerslev 1986), which assumes that the variance of future time series is a weighted average of past squared residuals and then forecasts the future variance conditional on the past information. Based on a GARCH model, we propose to examine

$$\begin{cases} r_t = \phi_{r,0} + \varepsilon_{r,t} \\ \varepsilon_{r,t} \sim i.i.d.N(0, H_{r,t}) \\ H_{r,t} = \beta_{r,0} + \beta_{r,1} H_{r,t-1} + \beta_{r,2} \varepsilon_{r,t-1}^2 \end{cases} \quad (1)$$

where the stock return is denoted by $r_t = \log P_t - \log P_{t-1}$ and $\beta_{\gamma,0}$, $\beta_{\gamma,1}$, *and* $\beta_{\gamma,2}$ are constant parameters. $H_{r,t}$ is the conditional volatility of stock returns, and $H_{r,t-1}$ is the lag term.

(2) Conditional volatility of stock message posting volume

Prior research mainly took two approaches to evaluate stock message postings. One is the content of the messages posted in stock discussion forums. For example, Tumarkin and Whiltelaw (2001) analyzed the average daily weighted posters' opinions of the stock's short- and long-term prospects. Wysocki (1999) and Liang et al. (Liang et al. 2006) studied the volume of messages. In order to avoid the problems of misinterpreting individual poster's opinions and subjectively screening out the "off-topic" messages, the cumulative volume of messages posted on the bulletin boards becomes a meaningful measure of information flows in stock discussion forums.

We apply the second approach by using the conditional volatility of abnormal posting volume, instead of original data from stock message volumes, to measure information transmission from stock message boards to stock markets. The message posting volume series are divided into two categories: postings during trading hours and postings during after-trading hours. It is difficult to differentiate the order of message posting activities and stock market activities because of the absence of high frequency data filtering. In order to investigate whether stock market performance responds to stock discussion postings, we choose to concentrate on the message posting volumes during after-trading hours. In the rest of the discussion, stock message posting volume only refers to the volume during after-trading hours for simplification purpose. Moreover, we use the conditional volatility of abnormal posting volume to measure how stock discussion forums affect stock returns.

The posting volume of new messages during period t, Ps_t, and the abnormal message posting volume Eps_t, are estimated in equations (2) and (3) separately.

$$PS_{t^*} = \mu + PS_{t-1^*} + PS_{t-2^*} + PS_{t-3^*} + \varepsilon_{Ps,t^*} \quad (2)$$

$$Eps_{t^*} = \hat{\varepsilon}_{Ps,t^*} \quad (3)$$

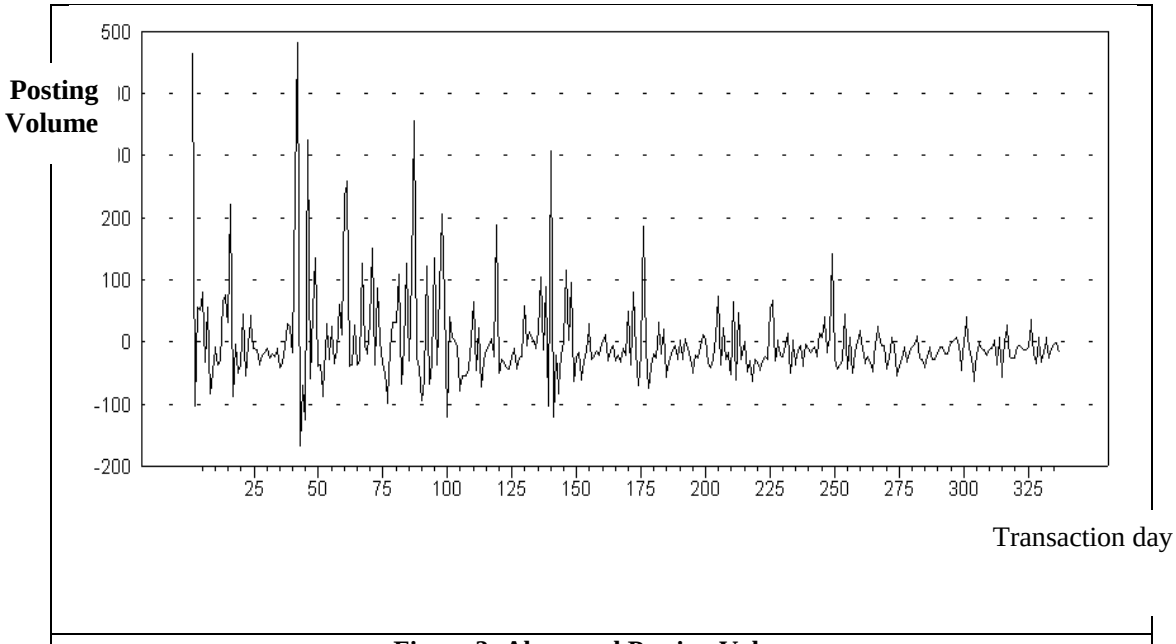

Figure 3: Abnormal Posting Volume

Figure 3 suggests that abnormal posting volume exhibits the phenomenon of volatility clustering, that is, periods in which the abnormal posting volume shows wide swings for an extended time period followed by periods in which there is relative calm. To avoid this problem, we choose the GARCH (1, 1) model in equation (4) to estimate the conditional volatility of the abnormal posting volume.

$$\begin{cases} Eps_{t^*} = \phi_{Eps,0} + \varepsilon_{Eps,t^*} \\ \varepsilon_{Eps,t^*} \sim i.i.d.N(0, H_{Eps,t^*}) \\ H_{Eps,t^*} = \beta_{Eps,0} + \beta_{Eps,1} H_{Eps,t-1^*} + \beta_{Eps,2} \varepsilon^2_{Eps,t-1^*} \end{cases} \quad (4)$$

where $H_{Eps,t}$ is the conditional volatility of abnormal stock message posting volumes, $H_{Eps,t-1}$ is the lag term, and $\beta_{Eps,0}$, $\beta_{Eps,1}$, *and* $\beta_{Eps,2}$ are constant parameters.

Econometric methodology

Because of the asymmetry between the stock market activities during trading hours and posting activities during after-trading hours, we use the Granger causality test (Granger et al. 1986) to explore the causality or the direction of influence between two time series, the message posting volatility and stock return volatility. Granger causality is a powerful tool to measure whether one time series happens before another and help predict it. To examine the Granger causality between the conditional volatility of message posting (Eps_t) and the conditional volatility of stock return (r_t), we set up the following model.

Assuming Eps_t and r_t are stationary, we have two information sets defined by $I_r(t-1) = \{r_{t-j}, j \geq 1\}$ and $I_{Eps}(t-1^*) = \{Eps_{t-j^*}, j \geq 1\}$, where $t-1$ and $t-1^*$ are two separate time periods. Let $I^0(t-1) = \{I_r(t-1), I_{Eps}(t-1^*)\}$ and $I^1(t-1) = \{I_r(t), I_{Eps}(t-1^*)\}$.

If $$E\{(r_t - \varepsilon_{r,t})^2 \mid I_r(t-1)\} \neq E\{(r_t - \varepsilon_{r,t})^2 \mid I^0(t-1)\} \quad (5)$$

r_t is said to be caused by Eps_t in variance, which means there is volatility spillover effect from the abnormal message posting volume to stock market returns.

If $$E\{(Eps_{t^*} - \varepsilon_{Eps,t^*})^2 \mid I_{Eps}(t-1^*)\} \neq E\{(Eps_{t^*} - \varepsilon_{Eps,t^*})^2 \mid I^1(t-1)\} \quad (6)$$

Eps_t is said to be caused by r_t in variance, which means there is volatility spillover effect from the stock market returns to the abnormal message posting volume.

In section 4.3, we used a GARCH (1, 1) model to measure the conditional volatility of message posting volume and stock returns. Cheung and Ng (Cheung et al. 1996) showed the Cross-Correlation Function (CCF) test to explore the causality in variance. The CCF approach is especially useful when the number of series under investigation is large and long lags in the causation pattern are expected.

Let U_t and V_t be the squares of standardized residuals of Eps_t and r_t.

$$U_t = \varepsilon^2_{Eps,t^*} \Big/ H_{Eps,t^*} \quad (7)$$

$$V_t = \varepsilon^2_{r,t} \Big/ H_{r,t} \quad (8)$$

where ε_{Eps,t^*} and $\varepsilon_{r,t}$ are the residuals of Eps_t and r_t separately, and H_{Eps,t^*} and $H_{r,t}$ are the conditional variances of Eps_t and r_t separately. Let $\rho_{uv}(k)$ be the sample cross-correlation at lag k, we have

$$\rho_{uv}(k) = c_{uv}(k)[c_{uu}(0)c_{vv}(0)]^{0.5} \quad (9)$$

where $c_{uv}(k)$ is the *k*th lag sample cross covariance given by $c_{uv}(k) = N^{-1}\sum(U_t - \bar{U})(V_{t-k} - \bar{V})$, $k = 0, \pm1, \pm2, \cdots$, c_{uu} (0) and c_{vv}(0) are the sample variances of U and V, respectively, and N is the sample size.

In section 3, we developed three hypotheses. We need to re-write these three hypotheses in an econometric model.

H1: There is transmission of information between stock markets and stock discussion forums.

Cheung and Ng (Cheung et al. 1996) found that if Granger causality is not detected between Eps_t and r_t, the sample cross correlation coefficient $\sqrt{N}\hat{\rho}_{uv}(k)$ follows the standard normal distribution. Following Cheung and Ng (1996), we have

$$S = N\sum_{i=-k}^{k}\hat{\rho}_{uv}(i)^2 \sim \chi^2(2k+1) \quad (10)$$

which has a chi-square distribution with $(2k + 1)$ degrees of freedom. We want to test the causality in variance between r_t and Eps_t at lag k. Equation (10) is used to test the hypothesis of no volatility spillover effect between the message posting volume and stock market returns from lag –k to lag k when there is no priori information on the direction of causality, which is *H1*.

H2: There is transmission of information from stock markets to "after-trading-hours" stock discussion forums.

In our paper, there is time asymmetry between Eps_t and r_t such that there is chronic direction of causality between the two time series even if lag k=0. Then there is

$$S_{uv} = N\sum_{i=0}^{k}\hat{\rho}_{uv}(i)^2 \sim \chi^2(k+1) \quad (11)$$

which is used to test the hypothesis of no volatility spillover effect from the stock market returns to the message posting volume from lag 0 to lag k. We need to test whether r_t causes Eps_t in variance at lag k, which is *H2*.

H3: There is transmission of information from "after-trading-hours" stock discussion forums to stock markets.

Using $\rho_{vu}(k) = c_{vu}(k)[c_{uu}(0)c_{vv}(0)]^{0.5}$, in which $c_{vu}(k) = N^{-1}\sum(U_{t-1-k} - \overline{U})(V_t - \overline{V})$, we have

$$S_{vu} = N\sum_{i=0}^{k}\hat{\rho}_{vu}(i)^2 \sim \chi^2(k+1) \qquad (12)$$

which is used to test the hypothesis of no volatility spillover effect from the message posting volume to the stock market returns from lag 0 to lag k. We need to test whether Eps_t causes r_t in variance at lag k, which is *H3*.

Empirical results

Descriptive statistics

Table 1 reports the descriptive statistics and the stationary Augmented Dickey-Fuller (ADF) test results for stock returns, stock message posting volume, and abnormal stock message posting volume. In table 1, $Q(k)$ and $Q^2(k)$ are the Ljung-Box test statistics for time series and square time series at lag k. There is significant autocorrelation in stock message posting volume, but there is no significant autocorrelation for stock returns and abnormal stock message posting volume. ADF test results suggest that the latter two observed time series are stationary.

Table 1. Descriptive Statistics

	Stock Returns	**"After-hours" stock message posting volume**	**Abnormal "after-hours" stock message posting volume**
Mean	-0.0023	115.3706	0
Standard Deviation	0.0267	86.1460	72.6396
Skewness	0.1278 [0.3373]	2.8475 [0.0000]	3.1289 [0.0000]
Kurtosis	0.9482 [0.0004]	11.0352 [0.0000]	14.3429 [0.0000]
J-B[1]	13.7027 [0.0010]	2184.6281 [0.0000]	3438.4741 [0.0000]
Q(4)	3.858 [0.4255]	214.208[0.0000]	1.779[0.7764]
Q(12)	7.618 [0.8142]	310.216[0.0000]	9.677[0.6442]
Q^2(4)	5.133[0.2739]	63.732[0.0000]	27.200 [0.0000]
Q^2(12)	13.487 [0.3349]	87.105 [0.0000]	28.346 [0.0049]
ADF	-18.7125 [0.0000]	-10.5855 [0.0000]	-20.0593 [0.0000]

* Standard errors computed under the normality assumption are in square parentheses.

GARCH result

Based on the ADF test results, we used GARCH (1, 1) model shown in equations (1) and (4) to measure the conditional volatility of the two stationary time series: stock returns and abnormal stock message posting volume. Maximum-likelihood method is used to estimate the coefficients of the conditional volatilities of stock returns and abnormal message posting volume in the GARCH (1, 1) model.

Table 2 presents maximum-likelihood estimates and diagnostic statistics of the GARCH (1, 1) model with two panels: stock returns (panel A) and abnormal message posting volume (panel B). Conditional volatilities of stock returns and abnormal message posting volume are affected by previous ones if $\beta_{r,1}$ and $\beta_{Eps,1}$ are significant at 5% level. This also supports that it is appropriate to use the GARCH (1, 1) model to estimate the conditional volatility of

[1] Jarque-Bera test of normality

stock returns and abnormal message posting volume. The CCF test, furthermore, can be applied to analyze the causality in variance between the two series.

Table 2: Maximum-likelihood estimates of the GARCH (1, 1) model

Parameter	Estimates	Standard Deviation	t - test	p value
Panel A: Stock returns				
$\phi_{r,0}$	-0.0028	0.0014	-1.9872	0.0469
$\beta_{r,0}$	0.0010	0.0002	5.0097	0.0000
$\beta_{r,1}$	-0.5330	0.2544	-2.095	0.0362
$\beta_{r,2}$	0.0756	0.0462	1.6353	0.1020
Panel B: Abnormal stock message posting volume				
$\phi_{Eps,0}$	-13.8268	1.9068	-7.2513	0.0000
$\beta_{Eps,0}$	189.7936	107.0585	1.7728	0.0763
$\beta_{Eps,1}$	0.5728	0.0660	8.6749	0.0000
$\beta_{Eps,2}$	0.7491	0.1611	4.6489	0.0000

CCF test results

The CCF causality in variance test results for stock returns and abnormal message posting volume are reported in table 3. In table 3, there are three null hypotheses (H_0): 1) no causality in variance between r_t and Eps_t ; 2) r_t does not cause Eps_t in variance, and 3) Eps_t does not cause r_t in variance. All of them can be rejected at 1% level. The CCF test results reveal that 1) there is volatility spillover effect between the message posting volume and stock market returns; 2) there is a positive volatility spillover effect from stock returns to abnormal message posting volumes; and 3) there is a negative volatility spillover effect from abnormal message posting volumes to stock market returns. When stock returns rise, investors are more willing (or more comfortable) to post messages to discuss the performance of stocks. If more posters posted their opinions about stocks in forums, however, there might be abnormal selling and buying of stocks in the stock market and stock returns will follow to fall. There is dual direction information transmission between the stock market and the stock discussion forums. Stock message postings can be used to help predict the stock market volatility.

Table 3: CCF test results for causality in variance

1. No causality in variance between	$S(3)$ =15.9358 [0.0012]	H_0 Rejected
2. does not cause in variance	$S_{uv}(2)$ =14.4456 [0.0007]	H_0 Rejected
3. does not cause in variance	$S_{vu}(2)$ =11.9977 [0.0025]	H_0 Rejected

* Lag 1 is used in the CCF test. Degrees of freedom are on round parentheses and standard errors computed under the normality assumption are in square parentheses.

Discussion and Conclusion

In this paper, we derive the conditional volatility of stock message posting volume and stock returns using a GARCH model to investigate the information transmission between the whole stock market and stock discussion forums in China. We find that there is a significant two-way volatility spillover effect between stock returns and abnormal message posting volume. There is a positive spillover effect from stock returns to abnormal message posting volume, and there is a negative spillover effect from the abnormal message posting volume to stock returns. The online stock discussion forums can be used to predict stock returns and stock market volatility. Our results may help investors to make investment decisions in emerging financial markets.

The results of this study have several implications. Not only academic researchers, but also corporate managers and government regulators are interested in tracking activities in online stock discussion forums. For academic researchers, we add to the literature by using a GARCH model to explore the relationship between the variation in stock returns and changes in stock discussion forums in developing countries. This helps to open a new path for future research in stock market related areas. From closely looking at abnormal activities in stock discussion forums, researchers can better predict stock market performance.

The research results also suggest that managers of listed company should monitor the stock discussion forums. Investors freely express their opinions about the company on online message boards. If managers feel that online messages are inaccurately portraying company pictures, they should clarify the correct information through news media or company web sites to influence stock returns.

Security regulators and the financial analysts have expressed concern that online discussions affect stock prices. Our results suggest that the concern is valid. There are many cases related to online message boards securities fraud (Federal Trade Commission 2007; Securities and Exchange Commission 2000). Security regulators need to scrutinize online stock forums constantly so as to prevent Internet investment scams and protect investors' interests.

Limitations

One of the issues that we do not investigate is whether the investor sentiments expressed in the online messages has predictive power for the stock markets. Future studies could examine if the return predictability that we find can be translated into a trading strategy with significant economic profits. In addition, we would like to add the Hong Kong Stock Exchange in our future research and compare results to the present study which focuses on Mainland China.

Although there are many factors that influence the stock markets and stock prices, our study is from the perspective of information transmission, which captures fundamental cause to influence the stock markets. We cannot control the third-party effects because we collected data from real stock markets and discussion boards.

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