An Empirical Research on Dynamic Relationship Between Yield Rate and Trading Volume in China's Stock Markets

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Abstract. Based on the econometric methods such as Vector Autoregressive model (VAR), Impulse Response Function (IRF) and Granger Causality Test, this paper investigates the dynamic relationships between yield rate and trading volume in Shenzhen and Shanghai stock markets. The study indicates that there is a strong mutual explanatory power between trading volume and yield rate. And the closer the historical trading day to current date is, the stronger the mutual explanatory power becomes. Furthermore, the Granger Causality Test shows that there is a bi-directional causality between yield rate and trading volume.

Introduction

The response of price to volume in the stock market remains the hot topic in the study of finance theory. The changes and the relationship between price-volume are factors and basis in the technical analysis. The accurate description of the relationship between stock price and volume is not only beneficial to deepen the understanding of financial market microstructure, explains the empirical distribution of the transaction prices reasonably, but also has the certain guiding significance in judging the market trend. The yield rate and trading volume are indicators commonly used in price-volume study, in consequence employing econometric methods such as the Vector Autoregressive model (VAR), Impulse Response Function (IRF) and Granger Causality Test, this article will do empirical research on the dynamic relationships between yield rate and trading volume in both Shanghai and Shenzhen stock markets and examine whether there exists Granger causality relationship between yield rate and trading volume. Furthermore the study discusses the information about trading volume in a dynamic environment whether helps to improve the yield prediction or not.

1. Literature review

Foreign researches on the price-volume relationship date back to the late 50's with the focus on the correlation studies between trading volume and price changes. According to Gallant, Rossi and Tauchen (1992), previous empirical studies on yield and volume were mainly concentrated on the connection between price changes and volume of the same period. Hereafter, the research priorities has transferred to the dynamic price-volume relationship. Wang (1994) analyzed the dynamic relationship between trading volume and returns on the basis of information asymmetry model. His model presented that trading volume can provide information about the expected returns. Chordia and Swaminathan (2000) also stated that trading volume plays an important role in the process of market information transmission by investigating the interaction between volume and measurability of short-term stocks' yields. Chen, Firth and Rui (2001) used the method of Granger Causality Test to study the dynamic relation between the stock index returns and trading volume empirically among nine major international stock markets, and they found the evidence that the yield is the Granger cause of volume and the volume is the Granger cause of yield.

Indeed, related domestic researches are mainly concentrated on the study of stock return volatility and relations between stock return volatility and trading volume. The generally used methods in their studies are various types of conditional heteroskedasticity model, such as the ARCH, GARCH, EGARCH and TARCH model, while the study of the dynamic relationship between yield rate and volume is relatively limited. Chenghui Wang, Chongfeng Wu (2002), RenHai Hua, Xiuling Ding

(2003) and Mingzhao Wang, Bing Guo (2006), respectively, draw the constructive conclusions from the preliminary researches on the method of Granger Causality Test, which verify the relation between index returns and trading volume and the relation between stock returns and trading volume. Nevertheless, above mentioned researches put particular emphasis on the analysis of Granger causality between yield and volume without analyzing the dynamic relationship between the two comprehensively. As a consequence, this article will be organized to demonstrate the dynamic relationship between yield rate and volume comprehensively and systematically by integrating Vector Autoregressive (VAR) model, Granger Causality Test and Impulse Response Function (IRF).

2. Data selection

The reform of shareholder structure was completed by the end of 2006, and the circuit-breaker mechanism in the stock market was implemented on January 1, 2016 and suspended on January 8. Considering these, to eliminate the effects on movement patterns of yield rate and trading volume caused by reform of shareholder structure and trading system changes, the trading data selected in this article cover the period from the first trading day in 2007 to the last trading day in 2015, i.e. from January 4 in 2007 to December 31 in 2015, composed of 2,188 trading days, and contain daily closing prices Pt and daily total volume Vt of the Shanghai composite index and Shenzhen composite index. Furthermore, in order to reduce the non-stationary data, all the data are processed by natural logarithm methods as LnPt and LnVt. And on this basis, the yield rate Rt is formed by Δ LnPt, as Rt = LnPt - LnP_{t-1}. All the data are derived from Tongdaxin software.

3. Methodology and Results of the empirical test

3.1 Series stationary test. The Autoregressive model (AR model) is mainly for the stationary time series modeling method, so the series stationary test must be conducted while using Vector Autoregressive model (VAR model). This article chooses the ADF unit root test to do the stationary test on the volume sequences LnVt and yield rate sequences Rt in both Shanghai and Shenzhen stock markets. The null hypothesis is that all sequences are the nonstationary sequences (i.e. there exists a unit root, r = 0). According to the Table 1 which describes the test results, under the significance level of 1%, the null hypotheses of having a unit root in daily yield rate and daily trading volume sequence of the Shanghai and Shenzhen composite index are rejected and indicate that the sequences are stationary.

Table 1 Result of ADF test

Variable	the type of test model(c, t, p)	ADF test Statistic	Mackinnon critical value		Null hypothesis(H0): Have a unit root (non-stationary)
			1%	5%	
LnVt (Shanghai stock market)	(c, t, 3)	-5.13017	-3.96224	-3.41186	Be rejected
LnVt (Shenzhen stock market)	(c, t, 3)	-5.89221	-3.96224	-3.41186	Be rejected
R_t (Shanghai stock market)	(0, 0, 0)	-45.43495	-2.56602	-1.94097	Be rejected
R_t (Shenzhen stock market)	(0, 0, 0)	-42.54174	-2.56602	-1.94097	Be rejected

Note:（c, t, p） offered the set type of test model, c, t, p represent constant term, trend term and lag order.

3.2 Vector Autoregressive model (VAR model). Traditional structure model commonly introduces the variables' relations by employing economic theory. However the economic theory usually cannot make strict interpretation on the dynamic relationship between variables, in addition, the interpretation and inference will be more difficult if the endogenous variables as the explained variables appear on both sides of the equation. Vector Autoregressive model (VAR) is one of the unstructured models to solve the problem well.

In VAR equations, each endogenous variable depends on its own lagged values and other endogenous variables. The data of VAR model comes from the Shanghai and Shenzhen stock markets respectively. Based on the criterion that the AIC and SC have the minimum amount of information tested by the VAR model, the most reasonable lag length is 4. The specific VAR model can be shown as Eq. 1 and Eq. 2.The parameter estimation results tested by VAR model are shown in the table 2. What should be mentioned is that the columns 2 and 4 show the parameter estimation of the data from

Shanghai stock market, while the parameter estimation of columns 3 and 5 is computed by the data from Shenzhen stock market.

$$LnV_t = c_1 + \sum_{i=1}^{4} \alpha_{1i} LnV_{t-i} + \sum_{j=1}^{4} \beta_{1j} R_{t-j} + \varepsilon_{1t} \quad (1)$$

$$R_t = c_2 + \sum_{j=1}^{4} \beta_{2j} R_{t-j} + \sum_{i=1}^{4} \alpha_{2i} LnV_{t-i} + \varepsilon_{2t} \quad (2)$$

Based on the data of Shanghai and Shenzhen stock markets, columns 2 and 3 of Table 2 show the parameter estimation results computed by Eq. 1. The results show that the coefficients of trading volume in the former four lag phases and the coefficients of yield rate in the last lag phase are significantly positive. The coefficients of yield rate and volume in every lag phase decrease gradually with the increased lag phases. This indicates that historical yield rate and volume have significant positive impacts on future volume in the short term. In other words, the increase of historical volume and yield rate in the short term will boost the increase of volume. The closer the time comes, the greater the impact becomes. In addition, the increase of yield rate in the last phase has an obvious promoting effect on the increase of current volume, which reflects the common price-volume relationship in the stock market that the volume increases with the price rises and vice versa.

Columns 4 and 5 of Table 2 show the parameter estimation results computed by Eq. 2, according to the data of Shanghai and Shenzhen stock markets. The results show that the last coefficients of trading volume and yield rate are significantly positive, and the coefficients of yield rate and volume in every phase decrease gradually with the increased lag phases. This illustrates that historical yield rate and volume have significant positive impacts on future yield rate in the short term. The closer the time comes, the greater the impact becomes. This phenomenon points to common price-volume relationship in the stock market, price rises while volume increases, vice versa. However compared to the results based on the Eq.1, the historical yield rate and volume in the short term have greater impact on the future volume than yield rate.

Furthermore, from the overall goodness of fit, the fitting effect of Eq. 1 is obviously better than that of Eq. 2, which can be discovered in both Shanghai and Shenzhen stock markets. The evidence that yield rate is the cause of the volume is more powerful than the evidence that the volume is the cause of yield rate. Based on the models and the samples, the overall fitting effect of Shenzhen stock market is slightly better than that of Shanghai.

Table 2 The parameter estimation results for VAR model

	Dependent variable			
	Trading volume（LnVt）		Yield rate （Rt）	
Independent Variable	coefficients of Shanghai stock market	coefficients of Shenzhen stock market	coefficients of Shanghai stock market	coefficients of Shenzhen stock market
LnV(t-1)	0.627517 [28.7833]	0.719563 [33.3916]	0.006704 [2.94320]	0.008894 [3.06494]
LnV (t-2)	0.144571 [5.64664]	0.084531 [3.19332]	-0.001675 [-0.62630]	-0.004073 [-1.14268]
LnV (t-3)	0.081699 [3.19568]	0.066369 [2.51804]	0.000114 [0.04254]	-0.000872 [-0.24581]
LnV (t-4)	0.110733 [5.17525]	0.1038 [4.93832]	-0.004153 [-1.85779]	-0.003002 [-1.06048]
R (t-1)	3.096283 [14.8063]	3.393472 [21.1064]	0.01418 [1.64908]	0.085617 [3.95439]
R (t-2)	-0.110889 [-0.50686]	-0.366537 [-2.08727]	-0.06496 [-2.84218]	-0.078509 [-3.31994]
R (t-3)	0.146096 [0.67288]	0.245222 [1.40215]	0.011353 [0.50050]	0.036645 [1.55596]
R (t-4)	-0.096082 [-0.45542]	0.051259 [0.30057]	0.005371 [2.96593]	0.007178 [1.61888]
C	0.659529 [5.54007]	0.464346 [5.26961]	-0.018269 [-1.46892]	-0.016526 [-1.39270]
R2	0.919230	0.952178	0.113882	0.119700
Adjusted R2	0.918934	0.952002	0.110261	0.116101

Note：The numbers in brackets indicate the T-statistic. R2 represents the Goodness of Fit.

Finally, to test the stability of the VAR model, the article analyzes the lag structure of VAR model, and the results indicate that all the eight unit roots' reciprocal values are less than 1, which are located in the unit circle. The VAR model is stable.

3.3 Granger Causality Test. The parameter estimation results of the VAR model initially show the causality relationship of the time series for yield rate and trading volume. In order to draw more definitive conclusion, the bidirectional Granger Causality Test is employed on the basis of the VAR model. Based on the principle of Granger Causality Test, the study firstly estimates the degree that how the current trading volume (or yield rate) can be explained by its own lag item, and then verifies whether the explanatory degree of yield rate (or trading volume) sequence can be increased by introducing lag sequence of yield (or volume). If the explanatory degree increases, yield rate (or trading volume) can be accepted as the Granger cause of trading volume (or yield rate). The null hypothesis of the test refers to that the yield rate (or trading volume) is not the Granger cause of trading volume (or yield rate), which means that yield's (or volume's) regression coefficients of lag phases in the regression equations are zero. This article adopts the model with lag phases of 4. And the table 3 below shows the test results.

Table 3 Granger Causality Test

	Shanghai stock market		Shenzhen stock market	
Null hypothesis	F-statistic	Probability	F-statistic	Probability
trading volume does not granger cause yield rate	3.09283	0.0150	2.82153	0.0238
yield rate does not granger cause trading volume	55.1700	0.0000	112.521	0.0000

When the lag length is 4, for the Shanghai and Shenzhen stock markets, the null hypothesis that the yield rate dose not Granger cause trading volume is refused. The probability of making a type I error is almost zero. Therefore the yield rate does Granger cause trading volume for both Shanghai and Shenzhen stock markets. Also under the confidence level of 95%, trading volume does Granger cause yield rate. In conclusion there is a bi-directional causality relationship between yield rate and trading volume for both stock markets. This conclusion shows that the yield rate and trading volume both contain extremely useful information to predict each other. So the validity of technical analysis has certain statistical basis in both Shanghai and Shenzhen markets.

3.4 Impulse Responses Function

Impulse response function is based on VAR model. The function is used to measure the response of endogenous variable's current value and future value to a standard deviation shock (i.e. innovation) of the random perturbation terms. According to the VAR (4) model formed by Eq.1 and Eq.2, if ε_{1t} (ε_{2t}) changes, not only the current trading volume (or yield rate) changes immediately, but also the future volume and yield rate will be affected by the value of current trading volume (or yield rate). The test results of the impulse response function are shown in the Fig. 1, Fig. 2, Fig. 3 and Fig. 4. Because the impulse response figures of the Shanghai and Shenzhen stock markets are nearly the same. The impulse response figures (i.e. Fig. 1 and Fig. 2) of Shanghai stock market are analyzed to discover the characteristics of the interaction relationship between trading volume and yield rate. First of all, the impulse response of trading volume and yield rate are more responsive to their own innovations than to innovations from each other.

Secondly, whatever innovations in trading volume or yield rate, the effects of impulse responses gradually diminish over time. But according to the decay rate, the response of volume and yield to innovations in volume dies down far more slowly than that in yield rate. The former impulse response still exists, even after the 20th trading days, while the latter almost disappears in the fifth trading day. Thirdly, from the Fig.1, the response of trading volume to innovations in itself is faster than the response of the yield rate to innovations in trading volume. When the shock has happened, the former reaches the maximum in the first trading day, while the latter reaches the maximum in the second trading day. Although both responses die down gradually in the following days, but are still positive.

Fourthly, as can be seen from the Fig. 2, the responses of trading volume and yield rate to innovations in yield rate are fast and positive. When the shock happens, both responses reach the maximum in the first trading day, and thereafter die down quickly. In addition, the responses of yield rate to its own shock turn to be negative on the third trading day, even though the negative impact is very weak. This indicates that the responses of yield rate to it self's innovations exist overreaction and then reverse adjustment.

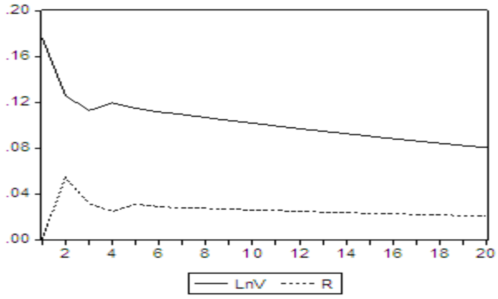

Figure 1.Impulse response of volume and yield rate to innovation in volume in Shanghai stock market

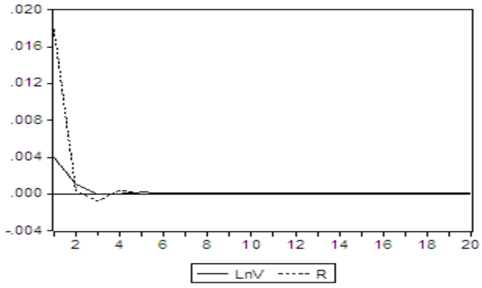

Figure 2.Impulse response of volume and yield rate to innovation in yield rate in Shanghai stock market

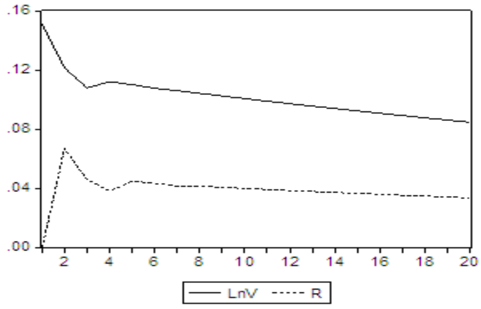

Figure 3.Impulse response of volume and yield rate to innovation in volume in Shenzhen stock market

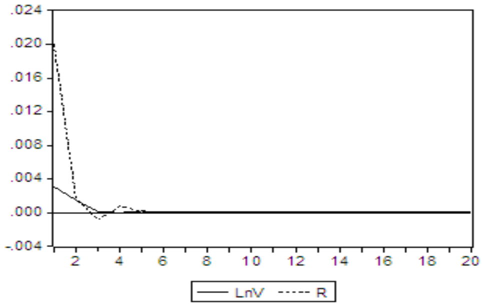

Figure 4.Impulse response of volume and yield rate to innovation in yield rate in Shenzhen stock market

4 Conclusions

The VAR models based on the data of the Shanghai and Shenzhen stock markets show that there is a stable relationship between yield rate and trading volume. And the two variables have a strong mutual explanatory power, with the closer the historical trading day to current date is, the stronger the mutual explanatory power becomes. The historical performances of trading volume and yield rate have positive impacts on the future trading volume and yield rate. The Granger Causality Test also shows that there is a bidirectional causality relationship between yield rate and trading volume, which provides not only the evidence for the prediction of one variable to another, but also the statistical basis of investors' judgment by using technical analysis. The impulse response analysis of yield rate and trading volume demonstrates that there is a significant interaction between yield rate and trading volume, but both of them have more influence on themselves rather than on each other.

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