

The Study of Stock Pricing Efficiency in Shanghai Stock Market

An Empirical Research Based on Spring Oscillator Theory

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Abstract—Academic studies concerning pricing efficiency of stock market mainly focus on whether the stock market is an efficiency market and the market form, but do not give quantitative indexes to measure pricing efficiency. In this article, we employed a state-of-art Spring Oscillator Theory to study pricing efficiency of the Shanghai Securities Exchange and especially, the quantitative analysis of stock price response to public information. We chose 50 typical listed stocks in the Shanghai Securities Exchange in our sample, and use annual report release to represent events that affect stock price. We made an empirical study on the relationship of pricing efficiency varies with time and correlation with the circulation size. Empirical results demonstrated that pricing efficiency went through a gradual declining during 2011-2013, and compared with 2009, the pricing efficiency of the stock market has been improved significantly in 2013. Additionally, no significant relations of stock pricing efficiency and its circulation size exist according to our empirical study.

Keywords-pricing efficiency of stock market; Spring Oscillator Theory; annual report; stock price; circulation size

I. INTRODUCTION

With the continuous development and perfection, Chinese securities market has become an important sector of the national economy. The high efficiency of the securities market can promote limited resources flow to departments or industry with high efficiency. Pricing efficiency of the stock market has been the focus of study. When study the problem of pricing efficiency, most scholars verify whether the market accord with the efficient market hypothesis or not, but do not give quantitative indexes to measure pricing efficiency. In this paper, we take Shanghai stock market as the research object and make quantitative analysis of stock pricing efficiency, and make an empirical study on the relationship of pricing efficiency varies with time and correlation with the circulation size.

II. LITERATURE REVIEW

"Efficient market hypothesis" put forward by Professor Fama at the University of Chicago believes that in an efficient market, market prices incorporate information at certain levels; price and value are equal at any time. According to different levels reflected by the information

of the stock prices, the efficient market hypothesis defines three types: weak form of efficient market, semi-strong form of efficient market and strong form of efficient market.

Fama (1965) study the dynamic behavior of 30 stocks in the Dow Jones Industrial Average Price between 1957 and 1962 years by using random walk model. The empirical results show that America securities market reached weak form of efficiency. The Shanghai stock market is divided into two stages (Song Songxing and Jin Weiyin, 1995). In the first stage (1991-1992) the scale of Shanghai stock market is still relatively small and still in the initial stage of development. In the second stage (1993-1994) the Shanghai stock market reaches a certain scale. Through their empirical analysis of the week returns ratioreflected in the second stage, they prove the random walk characteristics of Shanghai shares, therefore, the Shanghai stock market is weak efficient in the second stage. The root lies in the conclusion that the Shanghai stock market is non effective (Yu Qiao, 1994) is that the choice of the sample data including only the first stage, which is invalid.

As the financial system reform deepens continuously, the development of stock market in china is impressive, domestic scholars shift their focus to the effectiveness of semi-strong form market. Most of them use the "event study method" put forward by Fama, Fisher, Jensen and Roll. Through the study of the stock price movements before and after the events, test the semi-strong form efficiency of stock market. The first study to research China's stock market semi-strong form efficiency is to select the "Bao Yan event" and the "Wan Shen incident" two holding events, the empirical results show that at that time the securities market has not reached the semi strong form efficiency (ShenYifeng, 1996). Lin Lefen and Zhan Haijun select the reform of the shareholder structure as a major event and 1302 reformed companies as sample firms, they find that the reform on the stock market did not reach but near the semi-strong efficiency (2007). Select publication of annual report between 2004 and 2006 of 12 listed companies from hot industries in Shanghai and Shenzhen markets as major events. According to the different change trend of 12 industries in different years, the cumulative average

abnormal return ratio is divided into four levels and assigned respectively. Then quantify the abstract market efficiency simply, reach the overall efficiency of the capital market declining conclusion. QuBaozhong and XuQifan (2010) select the A-shares market M & A as major events. The purpose of the author is to verify the effectiveness of Chinese stock capital market in the new historical period has improved or not. The empirical results show that, compared to the weak efficiency before, efficiency of stock market in full circulation period China has improved greatly, close to the semi-strong efficiency. Most domestic scholars study the impact of economic policy or administrative regulations on the efficiency of the stock market, but rarely involved in political events (Wang Wenling and Pan Huifeng, 2012). They focus on the Political events such as 16th and 17th Party Congress, NPC and CPPCC to make quantitative in-depth research on the efficiency of stock market. The result of the research is the market responses significantly to these Political events, indicating that they have significant influence on the domestic stock market. But there exists both overreaction and lack reaction of political shocks, so the domestic stock market has not reached the semi strong efficiency.

Integrated the above documents, study on the pricing efficiency in the stock market of domestic and foreign scholars explore more on whether the market is in accordance with the "efficient market hypothesis", judging whether it has effective market effectiveness and belongs to which kinds of efficient market form. Zhao Zhenyu (2007) points out the defects of the efficient market hypothesis and puts forward the Spring Oscillator Theory, using the empirical model to study the pricing efficiency of spring oscillator theory. The empirical model of Spring Oscillator Theory produces the following relationship:

$$\begin{cases} p_t = a_0 + a_1 p_{t-1} + a_2 p_{t-2} + \varepsilon_t \\ \varepsilon_t^2 = c_0 + c_1 \varepsilon_{t-1}^2 + \delta_t \end{cases} \quad (1)$$

where δ_t satisfies white noise process. Spring Oscillator Theory not only make up the shortfall of effective market hypothesis, we can obtain the convergence speed to the new equilibrium of stock price, quantify the reaction efficiency. This paper will make further discussion based on the Spring Oscillator Theory.

III. METHODOLOGY

A. Data description

This paper chose annual report announcement of listed company as the important event, and studied the pricing efficiency of the stock market. The reason choosing annual report announcement as the important event was that annual report could reflect the listed company's financial position and operating results of last year. Investors made their strategic decision through analysis to annual report. And this would influence the stock price.

This paper sorted the A shares listed in Shanghai Stock Exchange in descending order by the circulation market value in November 4th, 2013. It chose 50 stocks by systematic sampling method as samples, and collected their 50 market days' closing price (including that day) after every annual report announcement from 2009 to 2013 as simple data. (The sample data was from Wind information)

In the sampling process, this paper resolved the below problems existing in sample stocks:

a. If the listed company that several sample stocks corresponds didn't launch in 2009, 2010, 2011 or 2012, we can't get the complete five years' data. This paper got rid of these stocks and chose the stocks that had complete data and were neighbouring as the sample stocks.

b. If the listed company that several sample stocks correspond to was exposed some important events such as merger and acquisition, stock right transfer, major reorganization of assets, and suspended announcement, these events would produce additive effect with annual report information and interfered it. This paper got rid of these stocks and chose the stocks that were neighbouring and didn't include these events in around 50 days of annual report announcing day as sample stocks.

c. The listed company that several sample stocks correspond to announced the annual profit distribution plan or preplan, and capital reserve funds to share capital plan or preplan in the 50 days of annual report announcing day. The plan or preplan that announced before was same with the information in annual report. This paper considered that annual profit distribution plan or preplan, and capital reserve funds to share capital plan or preplan after annual report were as known information and didn't produce additive effect with annual report information. These stocks could be as sample stocks.

d. If the listed company whose several sample stocks marked ST and *ST on the head of names had the continued loss, delisting alarm or was in a major reorganization of assets, the stocks marked had large risk and the biggest daily decline was limited to 5%. It limited the closing price of these stocks. This paper got rid of these stocks, and chose the stocks that were neighbouring and were not marked as sample stocks.

f. If the company that several sample stocks corresponded to announced the revised edition of annual report after several days of annual report announcing day, this paper would make the announcing day of revised edition annual report as the annual report announcing day. And it would do the empirical research to the 50 market days' data that were collected after annual report announcing day.

B. Empirical model and Results

According to the Spring Oscillator Theory, the stock price will fluctuate around the new fair value by the impact of the annual report of the firm. Assuming there is no other important information before and after, the price will gradually approach a new fair value. To illustrate this point clearly, we ignore the random error ε_t , and use model (2):

$$p_t = a_0 + a_1 p_{t-1} + a_2 p_{t-2} \quad (2)$$

when $t \rightarrow \infty$ (It means that if there is no other disturbing information, new fair value can abundantly reflect information contained in annual report after a period of time), p_t , p_{t-1} and p_{t-2} will approach a new fair value \hat{p} . It can be expressed mathematically below:

$$\hat{p} = \lim_{t \rightarrow \infty} p_t = \lim_{t \rightarrow \infty} p_{t-1} = \lim_{t \rightarrow \infty} p_{t-2} \quad (3)$$

when $t \rightarrow \infty$ we can get expression of the new fair value \hat{p} :

$$\hat{p} = \frac{a_0}{1 - a_1 - a_2} \quad (4)$$

Transposing the terms of equation (2), and setting the price series as unknowns, then we can get a difference equation:

$$p_t - a_1 p_{t-1} - a_2 p_{t-2} = a_0 \quad (5)$$

The new fair value \hat{p} is the special solution of the difference equation, and we assume the characteristic roots are λ_1 and λ_2 . So the general solution of difference equation can be expressed mathematically below:

$$p_t = \hat{p} + k_1 \lambda_1^t + k_2 \lambda_2^t + \varepsilon_t \quad (6)$$

k_1 and k_2 are arbitrary constants, and ε_t is random error of the stock price at time t . Equation (6) is simulated process of stock price fluctuation over time.

For empirical results, firstly we apply model(1) for regression of 50 sample stocks data in 5 years, and we can get predicted coefficients, and, which are then used to solve characteristic function and characteristic roots λ_1, λ_2 are obtained.

The result shows that one of the solutions is positive, and the value is close to 1, denoted as λ_1 ; while the sign of another solution are mixed, and the value is close to 0, denoted as λ_2 . This paper believes that the stock price has its inner stability, indicated by λ_1 ; the reaction characters of stock price reflected by information is indicated by λ_2 . With a small $|\lambda_2|$, the price converges to its fair value fast. And we decide to use $1/|\lambda_2|$ as proxy for pricing efficiency. Fig. 1 is a simple simulation stock process based on Spring Oscillator Theory, and the speed that stock price approach its fair value is positively connected with the value of $1/|\lambda_2|$.

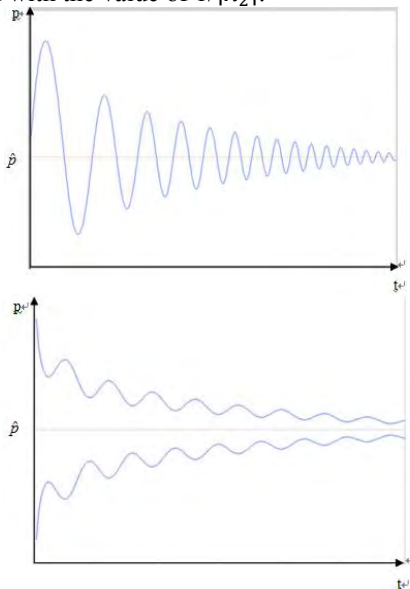


Figure 1. A simple simulation stock process based on Spring Oscillator Theory

According to the methodology, the pricing efficiency of 50 sample stocks from 2009 to 2013 can be calculated. The results are shown in Fig. 2.

Years Codes	2009	2010	2011	2012	2013
600016	9.68	4.56	2.93	13.83	32.47
600037	4.26	1.62	8.1	3.37	15.85
600086	4.53	2.82	34.36	4.59	5.43
600118	61.35	46.51	29.94	6.7	16.98
600127	2.62	12.27	10.61	3.63	12.13
6000165	7.26	5.85	4.35	166.67	3.19
600201	5.24	14.18	13.81	11.25	7.55
600215	17.45	172.41	4.29	8.46	17.73
600222	1.76	45.45	3.64	9.21	121.95
600241	15.24	5.12	144.93	9.43	270.27
600309	3.99	38.61	5.3	6.69	303.03
600350	8.73	5.28	32.57	14.9	23.81
600361	97.09	15.27	12.16	13.85	5.82
600362	14.55	16.36	19.57	7.39	22.32
600376	7.1	7.82	19.08	7.27	52.08
600382	3.71	12.02	8.92	7.02	46.08
600393	5.42	12.22	69.93	6.73	24.21
600415	28.01	4.78	4.54	5.29	22.52
600469	2.26	15.67	7.07	3.3	18.52
600470	5.66	59.52	79.36	4.17	5.09
600502	22.47	4.94	4.61	2.65	4.57
600503	10.18	15.5	20.45	4.18	11.11
600527	5.51	25.77	232.56	6.69	8.46
600531	62.5	13.57	10.31	17.6	6.49
600533	3.76	5.51	4.79	6.21	2.6
600584	1.87	4.43	38.91	100	100
600593	8.93	11.61	7.69	2.89	4.15
600596	1.62	9.72	63.29	11.86	4.13
600619	7.81	44.25	2.98	8.47	6.28
600628	2.04	7.23	36.63	25.38	4.28
600635	18.11	10.9	11.18	100	12.31
600665	8.1	13.83	8.46	20.24	9.18
600667	33.56	7.01	2.82	27.62	11.9
600708	101	16.05	10.72	10.17	42.37
600717	2.73	14.2	9.09	20.2	9.84
600759	10.92	3.72	18.15	35.09	7.93
600781	2.5	10.35	8.78	10.03	3.1
600824	19.08	18.18	34.84	2.13	6.59
600829	4.09	4.37	7.33	39.84	12.69
600834	7.76	5.51	2.19	5.26	5.61
600861	15.34	11.12	6.65	42.19	13.53
600963	3.99	22.62	4.77	7.4	5.13
600975	7.39	57.47	36.76	30.21	23.15
600982	22.12	7.57	23.31	15.43	3.18
600985	19.12	58.82	6.97	3.23	34.48
600986	9.57	13.05	7.21	7.25	6.04
601168	51.02	61.73	8.37	17.01	4.13
601588	2.9	4.23	13.37	32.89	17.45
601699	8.79	4.51	7.32	9.75	17.18
601808	6.49	13.57	16.1	16.53	34.25

Figure 2. The pricing efficiency of 50 sample stocks from 2009 to 2013

IV. EMPIRICAL RESULTS AND ANALYSIS

A. The pricing efficiency's variation over time

The first question we want to study is the pricing efficiency's variation from 2009 to 2013. We construct a dummy variable, as is defined below:

$$D_i = \begin{cases} 1 & k_{2010+t,i} > k_{2009+t,i} (t=0,1,2,3) \\ 0 & k_{2010+t,i} < k_{2009+t,i} \end{cases} \quad (7)$$

Where i represents different stocks. When the calculated stock efficiency is greater than the last year, demonstrating an improved pricing efficiency, D_i equals to 1. When the stock efficiency value less than the last year,

demonstrating a reduced pricing efficiency, D_i equals to 0. We defined another variable D'_i in order to compare the overall changes during five observation years.

$$D'_i = \begin{cases} 1 & k_{2013,i} > k_{2009,i} \\ 0 & k_{2013,i} < k_{2009,i} \end{cases} \quad (8)$$

Assuming D obey the Bernoulli distribution, i.e. $D \sim b(P)$. If number 1 appears significantly more than 0, it shows that the pricing efficiency of the stock market has been improved. Then, we construct the following hypothesis:

$H_0: p \leq 0.5$, the pricing efficiency of the stock market has been reduced.

$H_1: p > 0.5$, the pricing efficiency of the stock market has been improved.

TABLE I. HYPOTHESIS TESTING DATA

Years	$\sum D_i$	\bar{D}	z
2009&2010	30	0.6	1.414
2010&2011	21	0.42	-1.131
2011&2012	26	0.52	0.283
2012&2013	28	0.56	0.849
2009&2013	30	0.6	1.414

The results are shown in TABLE I. Firstly, consider the pricing efficiency's variation from 2009 to 2010. The Z statistic $z=1.414 > z_{0.1}=1.282$, so we reject the null hypothesis. Compared with 2009, the pricing efficiency of the stock market had been improved significantly in 2010. Then, consider the pricing efficiency's variation from 2010 to 2011. The Z statistic $z=-1.131 < z_{0.1}=1.282$, so we accept the null hypothesis. Compared with 2010, the pricing efficiency of the stock market had been reduced significantly in 2011. Similarly, compared with 2011, the pricing efficiency of the stock market had been reduced significantly in 2012, and compared with 2012, the pricing efficiency of the stock market had been reduced significantly in 2013. In general, consider the pricing efficiency's variation from 2009 to 2013. The Z statistic $z=1.414 > z_{0.1}=1.282$, so we reject the null hypothesis. Compared with 2009, the pricing efficiency of the stock market had been improved significantly in 2013. Therefore, we can conclude during five observation years, the pricing efficiency is the lowest in 2009, the highest in 2010, followed with 3 consecutive declining years till 2013. Overall, compared with 2009, the pricing efficiency of the stock market has been improved significantly in 2013.

B. Correlation between the stock efficiency and circulation size

We assume that the stock efficiency is positively correlated to circulation size. The reason is bigger listed firm with bigger circulation size could get more attention from investors and institutions. Thus the stock price can adjust quickly and accurately according to updated information, and the stock price converges to the new fair price fast.

This paper studies this problem by using Spearman's Rank correlation coefficient. Spearman's Rank correlation coefficient can describe the correlation degree and relationship between two variables. If the Spearman's Rank correlation coefficient is positive, it shows that the

variable is positively related to the other one. Otherwise, if Spearman's Rank correlation coefficient is negative, it shows that the 2 variable are negatively related. If our hypothesis holds, the Spearman's Rank correlation coefficient between the stock efficiency and circulation size should be significantly positive. Spearman's Rank correlation coefficient can be calculated by using MATLAB. The results are shown in TABLE II.

TABLE II. SPEARMAN'S RANK CORRELATION COEFFICIENT

Years	Spearman's Rank correlation coefficient	P value
2009	-0.0413	0.7756
2010	-0.1964	0.1716
2011	0.1105	0.4438
2012	0.0584	0.6868
2013	0.2025	0.1583

In general, as we can see, P value cannot pass significant test, indicating the assumption of positive correlation between stock pricing efficiency and its circulation size doesn't hold. In fact, no significant relations of these 2 variables exist according to our empirical study.

V. CONCLUSION

From the Spring Oscillator Theory viewpoint, this paper studies the pricing efficiency of Shanghai stock market with an empirical method, and we calculate the pricing efficiency of 50 sample stocks from 2009 to 2013. Our conclusions are as follows:

a. During five observation years, the pricing efficiency is lowest in 2009, the highest in 2010, followed with 3 consecutive declining years till 2013. Overall, compared with 2009, the pricing efficiency of the stock market has been improved significantly in 2013.

b. No significant relations of stock pricing efficiency and its circulation size exist according to our empirical study.

REFERENCES

- [1] Fama, Eugen, "The Behavior of Stock Market Prices", *Journal of Business*, Vol.38, No.1. (Jan., 1965), pp.34-105.
- [2] Fama, Eugen, "Efficient Capital Market: A Review of Theory and Empirical Work", *Journal of Finance*, Vol.25, No.2. (May, 1970), pp.383-417.
- [3] Song Songxing, Jin Weiyin. "The study on the effectiveness of Shanghai stock market". *Economist*, 1995(4), pp.107-128.
- [4] Yu Qiao. "Effective market, periodic abnormal and the fluctuation of stock price", *Economic Research Journal*, 1994(4), pp.43-50.
- [5] Shen Yifeng. "Accounting information disclosure and semi-strong form efficiency of Chinese stock market". *Accounting Research*, 1996(1), pp.14-17.
- [6] Lin Lefen, Zhan Haijun. "Effect of Non-Tradable-Share Reform in List Companies: an Empirical Study". *Journal of Nanjing University*, 2007(6), pp.118-141.
- [7] Yang Xionghui, Pan Qingyang, Fu Bo. "The response of stock market to the disclosure of events". *China Economist*, 2008(9), pp.92-93.
- [8] Qu Baozhong, Xu Qifan. "The study of semi-strong form efficiency of Chinese stock market after the shares are full circulation". *Statistics and Decision*, 2010(9), pp.133-135.
- [9] Wang Wenling, Pan Hui Feng. "An event study on the impact of important political events on China stock market". *Scientific Decision-Making*, 2012(9), pp.39-72.

- [10] Zhao Zhenyu, Ouyang Lingnan, Zhu Bo. "The new theorem of using Spring Oscillator Theory to study capital market". *Control Theory & Applications*. 2005(2), pp.76-80.
- [11] Zhao Zhenyu, Ouyang Lingnan, Zhu Bo. "Spring oscillator theory and empirical research on Shanghai stock market". *Journal of management sciences in China*. 2007(6), pp.71-79.
- [12] Zhao Zhenyu, *The pricing research on the security assets*, Economy & Management Press, 2012.
- [13] Gao Tiemei, *Econometric analysis and modeling*, Tsinghua University Press, 2006.