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A Study on Market Efficiency with the Indexes of SSEC and SZSEC of China*

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Abstract

This paper studies market efficiency from a weak form aspect using opening and closing prices of the Shanghai stock exchange composite index (SSEC) and Shenzhen stock exchange composite index (SZSEC) under the expected return theory. Classical methods (autocorrelation and runs test) are used to examine the features of stock returns, and little evidence against mutual independence of returns is found. We predict daily returns of SSEC and SZSEC with AR(p) and VAR(p) models (in this paper, $p = 5$ is taken as a one-week lag) and perform a virtual experiment on two indexes based on the predicted value of daily returns from AR(p) or VAR(p) model. From the results of AR(p) and VAR(p) for two indexes, we attempt to find out how the market efficiency level changes when the information from the other market is under consideration as we check the market efficiency level in one market. We find that SSEC in 2014–2016 and SZSEC in 2015–2016 are inefficient from the result of autocorrelation, that SSEC in 2016 and SZSEC in 2013 are not efficient from the result of runs test, that the stock market is efficient except 2005, 2009, 2010 and 2017 in SSEC and 2005, 2016 and 2017 in SZSEC and that SSEC is more influenced by SZSEC but SSEC influences SZSEC less from the result of the virtual experiment.

Keywords: Stock Market, Stock Returns, Efficient Market Hypothesis

JEL Classification Code: C12, G12, G14

1. Introduction

Up till now, many studies have been conducted on efficient capital markets. However, for people who started studying problems of efficient capital markets, the first problem they encountered was how to define the word ‘efficient’. One famous paper, Malkiel and Fama (1970), which summarizes important theory and empirical work on efficient capital markets, has been playing a significant role in the development of studies on market efficiency. This famous paper perfectly summarizes studies before 1970, giving the other economists a detailed reference which is useful for keeping on doing deeper research. It says that a market in which prices always fully reflect available information is called efficient. However, it was unable to make any progress if the theory about efficient markets was stated only in simple words but not in mathematical or statistical forms. Transforming simple words into mathematical or statistical form, or more specifically, into concrete and verifiable models is not only important but also difficult. It may have been the next difficulty during that time after the definition of ‘efficient’. Fortunately, it had already been solved to some extent by economists. Malkiel and Fama (1970) summarize ‘expected return theories’ or ‘fair game models’, which were assumed in available work then. The details of this model will be reviewed in Section 2 of this paper. Under this theory, two types of assumptions about security price are developed. First is the random walk hypothesis assuming that price follows a random walk and returns should be unpredictable.

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Lots of studies researching with various stock return data from different markets have tested random walk features. Second, the sub-martingale hypothesis assumes that stock price is constantly rising. Researches on the sub-martingale model are another important part of empirical studies on market efficiency. Malkiel (2003) also treats the definition that such markets do not allow investors to earn above-average returns without accepting above-average risks as the definition of an efficient market.

There are lots of findings on stock prices, returns, and market efficiency. Early in Fama (1965), the random walk theory in stock prices is briefly discussed. Fama and French (1988) say that the autocorrelation in returns is weak for the daily and weekly holding periods but stronger for long-horizon returns. Ding et al. (1993) investigated the 'long memory' property of stock returns. They find that there is more correlation between absolute returns than returns themselves and that the power transformation of the absolute return $|rt|^d$ has quite a high autocorrelation for long lags. Chen and Yeh (1997) confirm short-term nonlinear regularities exist in TAISE and S&P, but the search costs of discovering them might be so high that the market is still efficient. Ojah and Karemera (1999) find evidence supporting random walks, and weak-form efficiency in major American emerging equity markets, and investors could not make profitable trading schemes using historical information. Smith et al. (2002) study the African stock market's random walk model. Only the South African market follows the model. Özdemir (2008) studies the efficient market hypothesis for the Istanbul Stock Exchange National (ISEN) 100 price index. They use the ADF unit root test, runs test, and variance-ratio test. They conclude that ISE is a weak form efficient market.

Borges (2010) tested the weak form market efficiency of indexes of France, Germany, the UK, Greece, Portugal, and Spain. It is found with convincing evidence that monthly prices and returns follow random walks, but daily returns are not normally distributed with negative skewness and kurtosis over three. Sewell (2012) made a specific study on Dow Jones Industrial Average log returns by using daily, weekly, monthly and annual data. It is found that first-order autocorrelation is small but positive for all time periods. However, autocorrection close to zero is consistent with an efficient market for daily and weekly returns, while the standard runs test is rejected for daily returns but not rejected for the others. Nisar and Hanif (2012) examine the weak-form market efficiency on four major stock exchanges in South Asia including, India, Pakistan, Bangladesh, and Sri Lanka. They conclude that none of the four major stock markets of South Asia follow a random walk. Therefore they think all these markets are not weak-form efficient markets. Degutis and Novickytė (2014) believe that investors could not earn excess profits although stock market anomalies exist. Ţiţan (2015) reviews the growing body of empirical research on the efficient market hypothesis. It says there are many opposite views regarding the efficient market hypothesis: some of them reject it while others support it. It stresses the truth that testing market efficiency is difficult and a new theoretical model has to be developed. Rossi (2015) summarizes studies on calendar anomalies of markets, such as the January effect, day-of-the-week effect, and turn-of-the-month effect, and says that the evidence against the efficient market hypothesis has grown. Lu and Gao (2016) test the presence of the day of the week effect on stock returns in Chinese stock exchanges and find a positive effect on Mondays and a negative effect on Thursdays. Malafeyev et al. (2019) studied the Bombay stock exchange and Shanghai stock exchange composite index. They find evidence against weak form market efficiency as well. Camba and Camba (2020) provide evidence of the existence of random walks in the Philippine stock market and consider the market is weak-form efficient. Duan and Tanizaki (2021) find some inefficiency in Chinese stock markets from 2005 to 2018. The findings of Prabodini and Rathnasingha (2022) support the semi-strong form efficient market hypothesis because stock prices adapt so quickly to public information in the Colombo Stock Exchange.

This paper examines market efficiency in Chinese stock markets, using Shanghai stock exchange composite index (SSEC) and Shenzhen stock exchange composite index (SZSEC). In the past, a lot of papers have tested market efficiency in a weak form. They have attempted to study different stock markets in the world with statistical tests. As discussed in Ţiţan (2015), however, some papers support market efficiency while the other ones do not. This paper also works on a new question: how does the market efficiency level change when information from the other market is under consideration as we test the market efficiency level in one market?

The sections of this paper are arranged as follows. Section 2 sketches out the theory under which the research is done and states how this paper studies the problem of market efficiency. Section 3 introduces the data. Section 4 shows the empirical results of the tests and draws some conclusions. Section 5 summarizes the paper.

2. Methodology

Based on Malkiel and Fama (1970), the theory of market efficiency mainly means 'expected return models, which can be described as:

$$E(p_{t+1} / \Phi_t) = [1 + E(R_{t+1} / \Phi_t)]p_t \quad (1)$$

where p_{t+1} denotes the price of a security (stock index in this paper) at time $t + 1$, R_{t+1} denotes the return of security (stock index) at time $t + 1$, E(•) denotes the expectation operator and Φ_t denotes the information set at time t. The dots above p_{t+1} and R_{t+1} mean that they are random variables at time t. The most important implication of this theory is that it rules out the possibility of the trading system have expected returns in excess of equilibrium return:

$$x_{t+1} = p_{t+1} - E(p_{t+1} / \Phi_t) \quad (2)$$

$$E(x_{t+1} / \Phi_t) = 0 \quad (3)$$

$$z_{t+1} = R_{t+1} - E(R_{t+1} / \Phi_t) \quad (4)$$

$$\mathrm{E}(z_{t+1}/\Phi_t) = 0 \quad (5)$$

where x_{t+1} denotes the difference between the real price and the expected price at time $t + 1$ and z_{t+1} denotes the excess return at time $t + 1$. The dots above p_{t+1}, x_{t+1}, R_{t+1} and z_{t+1} mean that they are random variables at time t. Under the definition of x_{t+1} in (2), (3) will hold and under the definition of z_{t+1} in (4), (5) will hold.

The main purposes of this paper are to examine: (i) whether stock markets are weakly efficient in China, and (ii) whether the level of market efficiency changes over time and how it changes.

2.1. Autocorrelation Test

We examine the autocorrelation feature in daily returns. If the random walk model of stock price stands up, the return series of the stock price denoted by R_t (t = 1, 2, 3, …, n) should be mutually independent, where R_t denotes the return of stock price at the time t. If R_t (t = 1, 2, 3, …, n) is independent, it is impossible to predict tomorrow's return with past returns, and therefore the market is efficient. Let ρ_k be the autocorrelation function between R_t and R_{t-k}. To test the hypothesis of whether the returns are independently distributed or not (i.e., whether the stock market is efficient), we use the Ljung-Box test (Ljung & Box, 1978), which may be defined as:

$$\mathrm{H}_0\text{: } \rho_1 = \rho_2 = \ldots = \rho_\mathrm{h} = 0, \qquad \mathrm{H}_1\text{: not } \mathrm{H}_0$$

where ρ_k (i = 1, … , h) denotes the kth-order autocorrelation. If there is significant autocorrelation in one year, the market is inefficient in that year. In Section 4.1, using the Ljung-Box test we investigate market efficiency every year, where one-year data is utilized (for example, 242 daily data in 2005 are available).

2.2. Runs Test

We check the sign change of the return series with the runs test (Özdemir (2008) and Sewell (2012)). The null hypothesis of the runs test is that the elements of the sequence are mutually independent. If a market is efficient, the number of runs should be random, i.e., the number of observed runs of a return series should not be statistically higher or lower than the number of mean runs. If the number of observed runs is significantly higher or lower, the hypothesis of return independency will be rejected, and the market is not efficient. In Section 4.2, we check market efficiency every year.

2.3. Two-Sample Test of Means

It has been discussed that the implication is involved in the expected return theory: profitable strategies cannot exist. We will do a virtual experiment to see if they are profitable with the method: we use some daily returns calculated by the closing price of the index before time t to predict the return at time t, which is used as the critical value for buying or selling action, and use the opening price at time t to construct the virtual experiment. It should be noted that transaction costs are not considered when we perform buying or selling actions in a virtual experiment.

Using past one-year closing price data, R_t is estimated daily for both SSEC and SZSEC with AR(p) and VAR(p) models. The conventional OLS is adopted for estimation. Using one year of data up to time t, the return at time $t + 1$ is forecasted, and its forecasted value is denoted by $\hat{R}_{t+1}$. The forecasted value is updated every time the closing data of stock price is added. Thus, we can obtain a series of forecasted values every day from the beginning of 2005 to the end of 2018. In Section 4.3, $p = 5$ (i.e., one week lag) is taken.

To check market efficiency, in this section, we consider the virtual experiment on buying and selling one share along the following rule: (i) initially we do not have a share, (ii) when $\hat{R}_t$ is greater than $a * 10^{-5}$ for the first time (10^{-5} is multiplied due to decimal adjustment), we decide to buy one share at the opening price of time t, (iii) after buying one share, when $\hat{R}_t$ is less than $b * 10^{-5}$ for the first time (remember that $\hat{R}_t$ is computed at time t–1 after obtaining the closing data of time t–1), we decide to sell one share at the opening price of time t (that is, we have no share at this stage), and (iv) we repeat (ii) and (iii) from the beginning of 2005 to the end of 2018. Depending on a and b, we examine whether the return rate with one share is different from the return rate with no share. In Section 4.3, we take (a, b) = (–1, –10), (–1, –5), (–1, –1), (0, –10), (0, –5), (0, –1), (1, –10), (1, –5), (1, –1). The null hypothesis and alternative hypothesis for judging an efficient market are:

$$\mathrm{H}_0\text{: } \mu_{\mathrm{HR}} = \mu_{\mathrm{NHR}},\ \mathrm{H}_1\text{: } \mu_{\mathrm{HR}} \neq \mu_{\mathrm{NHR}}$$

where μ_{HR} denotes the population mean of the return rate of holding one share and μ_{NHR} denotes the population mean of the return rate of not holding one share. If the stock market is efficient, H_0 is accepted. Using a standard normal distribution approximately, we perform the two-sample test of means every year.

Furthermore, to check whether SSEC (or SZSEC) influences SZSEC (or SSEC), we estimate the two-variate VAR(p) model and perform the same virtual experiment as discussed above. The null hypothesis and alternative hypothesis are the same as the ones stated above. If the null hypothesis is rejected, we can say that the market is inefficient.

3. Data

The data used in this paper is the closing prices of the Shanghai stock exchange composite index (SSE composite index or SSEC) collected from Shanghai Stock Exchange Statistics Annuals (http://www.sse.com.cn/aboutus/publication/yearly/) and monthly magazines (http://www.sse.com.cn/aboutus/publication/monthly/) and of Shenzhen, stock exchange composite index (SZSE composite index or SZSEC) collected from Shenzhen Stock Exchange Statistics Fact Book (http://www.szse.cn/market/ periodical/year/ index.html) and monthly magazines (http://www.szse.cn/ market/periodical/month/ index.html) and the opening prices of SSEC and SZSEC contained from NetEase Finance (https://money. 163.com) from January 4th, 2005 to December 31st, 2018. In this paper, the daily return is calculated as $R_t = \ln P_t - \ln P_{t-1}$, where R_t denotes the daily return of stock index at time t, and P_t denotes the closing price of stock index at time t.

Figure 1 shows the evolution of three indicators in two stock exchanges: the number of Listed companies, the number of Listed stocks, and one year's Trading value from 2005 to 2018. The horizontal axis indicates the year. The vertical axes indicate the number of Listed companies and Listed stocks on the left axis and the amount of Trading value with units of 100 million yuan on the right axis. The circles indicate the data of SSE, and the triangles indicate the data of SZSE. From the solid and dotted lines with circles and triangles in Figure 1, in 2005, there were only 833 listed companies, 878 listed stocks in SSE, and 544 and 586 in SZSE. From the dashed lines with circles and triangles in Figure 1, the stock trading value was 1, 924, 021 million yuan in SSE and 1, 242, 457 million yuan in SZSE. It seems that SSE developed more quickly and better than SZSE. While after 2009, the numbers of listed companies and stocks in SZSE were more than those in SSE, and after 2015 the trading value of SZSE was also higher than that of SSE. It seems that SZSE began to outperform SSE. Despite that, both stock exchanges have been growing at high speed. In Section 4.3, the information listed in Figure 1 will appear for analysis of market efficiency.

4. Empirical Results

To check when the stock market is efficient, the Ljung-Box test (Section 2.1), the runs test (Section 2.2), and the mean difference test based on the virtual experiments (Section 2.3) are performed using SSEC and SZSEC data each year. 242 stock price daily data in 2005, 241 data in 2006, …, and 243 data in 2018 are available. The results of the Ljung-Box test and the runs test are in Figures 2 and 3. The results of the virtual experiments are in Figures 4 and 5.

4.1. Autocorrelation Test

In this section, using the Ljung-Box test, we discuss whether stock returns are autocorrelated. In Figure 2, the vertical axis indicates the P value and the horizontal axis represents the year. The solid line, the dashed line, and the dotted line represent SSEC, SZSEC, and 5% significance level, respectively. In the case where the solid line or the dashed line is below the dotted line, the null hypothesis is rejected at a 5% significance level, and accordingly, the corresponding stock market is not efficient. That is, Figure 2 indicates that SSEC in 2014–2016 and SZSEC in 2015–2016 are inefficient. The possible reason that the stock markets

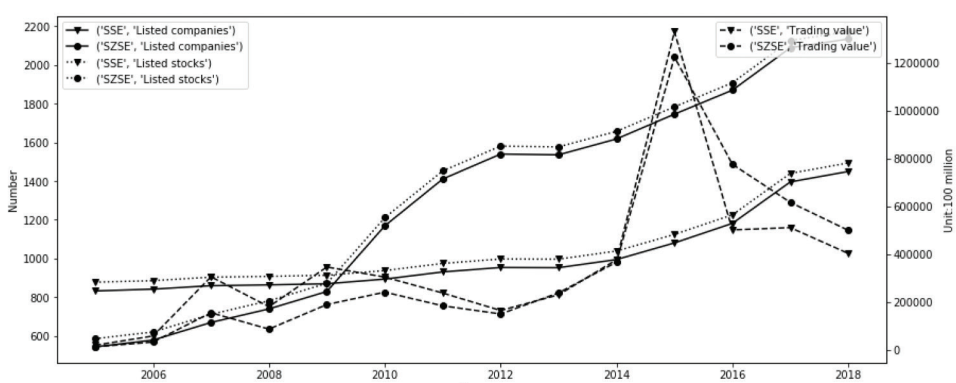

Figure 1: The Overview of SSE and SZSE

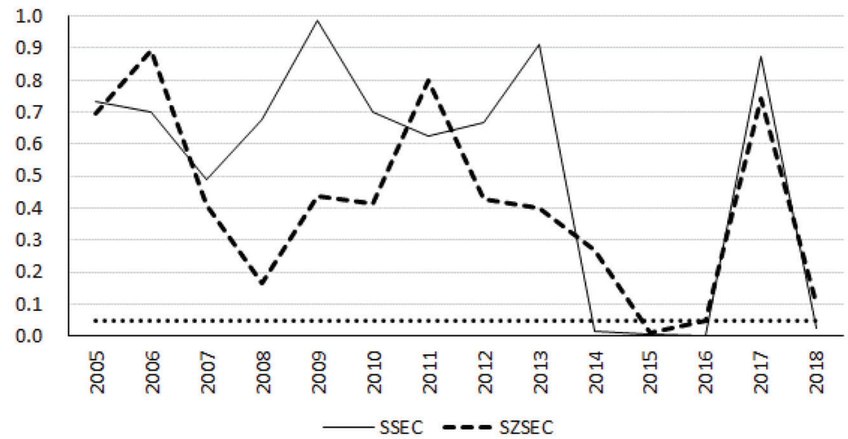

Figure 2: Ljung-Box Test

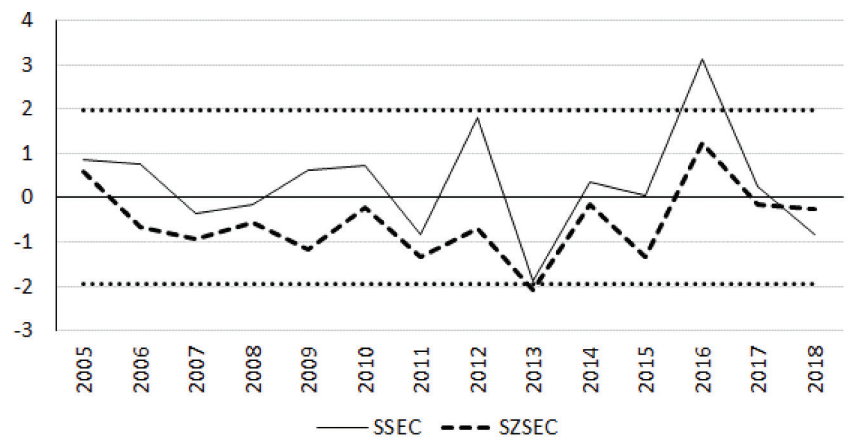

Figure 3: Runs Test

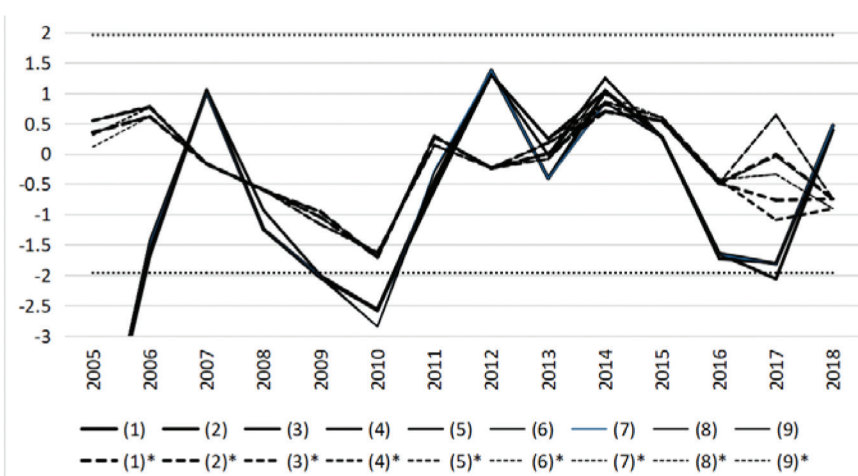

Figure 4: SSEC Results

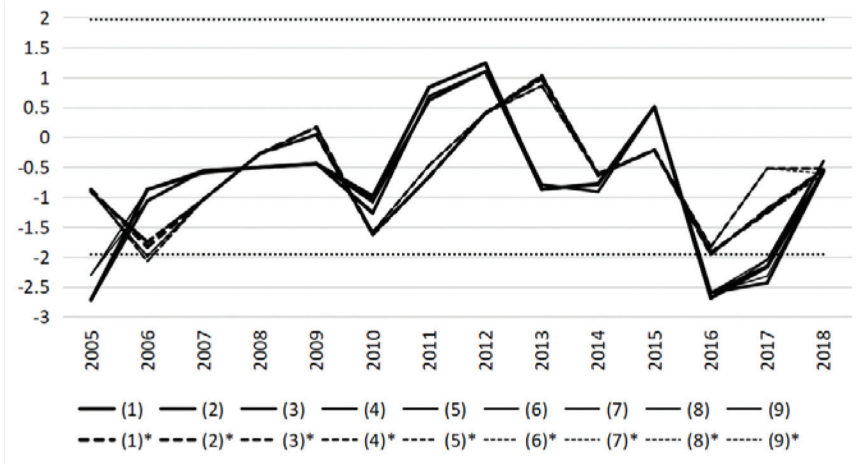

Figure 5: SZSEC Results

were inefficient around 2015 is considered that the markets were suffering a crash in China.

4.2. Runs Test

In this section, using the runs test discussed in Section 2.2, we consider whether the number of runs on stock returns is random. In Figure 3, the vertical axis indicates the run test statistics normalized to be mean zero and variance one, while the horizontal axis is the year. The solid line, the dashed line, and the two dotted lines represent SSEC, SZSEC, and 95% confidence interval (–1.96, 1.96), respectively. If the solid line or the dashed line is above 1.96 or below –1.96, the stock market is inefficient. From the result in Figure 3, we can observe that SSEC in 2016 and SZSEC in 2013 are not efficient. According to China Securities Regulatory Commission (2014), the possible reasons that the stock market is inefficient in 2013 are considered as follows: (i) because of a program error, the trading system of Everbright Securities Company Limited made abnormal tradings which caused the indexes to dramatically fluctuate in a short time, and (ii) the China Securities Regulatory Commission released a plan in November 2013 to overhaul the nation's IPO system and the reform plan which meant new opportunities for Chinese investors was long awaited. The possible reason that the stock market was inefficient in 2016 is considered that the market was suffering a crash in China around 2015.

4.3. Two-Sample Test of Means

In this section, we examine whether the rate of return during the periods when we have one share is different from the rate of return during the periods when we do not have a share. We test the difference between the two means every year, as shown in Section 2.3 of the testing procedure. The results of the mean difference test based on the virtual experiments are in Figures 4 and 5, where 18 lines and the 95% confidence interval (–1.96, 1.96) are drawn. The 18 lines correspond to the test statistics from 2005 to 2018. (1)–(9) represent the cases of (a, b) = (–1, –10), (–1, –5), (–1, –1), (0, –10), (0, –5), (0, –1), (1, –10), (1, –5), (1, –1), respectively. * indicates the results of VAR(5), where we investigate whether one stock market influences another stock market. Note that AR(5) does not take into account the other stock market.

For both Figures 4 and 5, the solid lines of (1)–(9) are overlapped, and the dashed lines of (1)*–(9)* are also overlapped. We cannot distinguish each line, but we can see the difference between AR(5) and VAR(5), i.e., between the solid lines and the dashed lines. We can observe that the rate of return does not depend on the buying-and-selling rule for any a and b because the solid lines (1)–(9) are overlapped, and the dashed lines (1)*–(9)* are also overlapped. As shown in Figures 4 and 5, the stock market is efficient except in 2005, 2009, 2010 and 2017 (when b = –5) in SSEC with AR(5) and 2005, 2016 and 2017 in SZSEC with AR(5). Especially, the SSEC market became efficient in 2005, 2009, 2010 and 2017 by taking into account the SZSEC market, but the SZSEC market is inefficient in 2006 (b = –10) even though information on SSEC was utilized. We can interpret that SSEC is more influenced by SZSEC but SSEC influences SZSEC less because the market size in SZSEC is more significant than that in SSEC after 2009, judging from Figure 1.

5. Conclusion

This paper has studied market efficiency level in Chinese stock markets under expected return theory from the weak form aspect using the closing and opening prices of the Shanghai stock exchange composite index (SSEC) and Shenzhen stock exchange composite index (SZSEC) from January 4th, 2005 to December 31st, 2018.

Using the three tests in Sections 2.1–2.3, we have discussed whether the stock markets of SSEC and SZSEC are efficient or not. We have obtained the results: (i) both markets are efficient for most periods. We have found that SSEC in 2014–2016 and SZSEC in 2015–2016 are inefficient from the view of autocorrelation (see Figure 2 in Section 4.1), (ii) SSEC in 2016 and SZSEC in 2013 are inefficient from the view of runs test (see Figure 3 in Section 4.2), (iii) the stock market is efficient except 2005, 2009, 2010 and 2017 in SSEC and 2005, 2016 and 2017 in SZSEC (see Figures 4 and 5 in Section 4.3), and (iv) SSEC is more influenced by SZSEC but SSEC influences SZSEC less from the view of virtual experiments (see VAR(5) in Figures 4 and 5 of Section 4.3).

The possible reasons that the stock market was inefficient in 2005, 2010, 2013, 2016 and 2017 are considered as: (i) in 2005, in order to promote the work of share splitting reform, which was a big event in Chinese capital markets, China Securities Regulatory Commission (CSRC) held a meeting and made some arrangements and the work of share splitting reform was steadily proceeding in September, 2005, (ii) from China Securities Regulatory Commission (2011), from April 8th, 2010, Stock Price Index Futures formally started and in April 16th CSI 300 stock price index future was formally listed and traded on China Financial Futures Exchange, (iii) in 2013, because of program error, the trading system of Everbright Securities Company Limited made abnormal tradings which caused the indexes to dramatically fluctuate in a short time, and China Securities Regulatory Commission (2014) released a plan in November 2013 to overhaul the nation's IPO system and the reform plan which meant new opportunities for Chinese investors was long awaited, (iv) from China Securities Regulatory Commission (2017), from December 5th, 2016, the mechanism of Shenzhen-Hong Kong Stock Connect formally started, by which investors from two markets (Shenzhen stock market and Hong Kong stock market) could buy and sell some stocks (meeting certain conditions) listed on the other side's exchange, and (v) from China Securities Regulatory Commission (2018), in June, 2017, MSCI announced the inclusion of China A Shares in the MSCI Emerging Markets Index and Global Benchmark Index from June, 2018, which was seen as a milestone in the process of Chinese capital markets opening to the outside world and indicated the confidence on Chinese capital markets from global investors. Furthermore, the possible reason that the stock markets were inefficient around 2015 is considered that the markets were suffering a crash in China.

Thus, we can conclude that the stock price markets of SSEC and SZSEC are efficient except for periods of specific economic situations and that SZSEC influences SSEC more.

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