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Bachelor's Thesis in Financial Economics

Study of the Weak-form Efficient Market Hypothesis

Evidence from the Chinese Stock Market

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Abstract

This paper examines the Chinese stock market efficiency through validation of the weak-form efficient market hypothesis of the Shanghai and Shenzhen stock exchanges. Also, the paper attempts to determine the presence of daily calendar effects on the Chinese stock market.

Stock market returns ranging from 1992 to 2015 are used for three price indices of the Shanghai and Shenzhen market, namely the A-share, B-share and Composite indices. The stock market efficiency is tested for each index by applying various statistical techniques such as tests for autocorrelation, runs, and variance ratio. The daily calendar effect is determined through an ordinary least squares regression model.

We find that the generated results are consistent with previously conducted studies, which state that the Chinese stock markets are not weak-form efficient. According to the results from the autocorrelation test, runs test and variance ratio test, the random walk hypothesis is denied in all three instances in both Chinese markets. Even though B-share indices in both markets consistently exhibit a lesser degree of randomness compared to A-share and Composite indices, the latter two show signs of increasing efficiency between 1992 and 2012. Regarding the daily calendar effect, the results that all three indices in both markets exhibit at least one significant day of the week effect throughout the whole period.

JEL Classification: G14, G15
Keywords: market efficiency, efficient market hypothesis, weak-form efficiency, random walk, Chinese stock market, variance ratio test, daily calendar effect.

Contents

1 | Introduction

1.1 Background

Ever since the introduction of the concept that stock prices and returns mimic a pattern reminiscent of a random walk, the general opinion amongst researchers and analysts within the field of financial economics have largely been coherent. This concept of randomness stems from empirical observations that stock prices or returns have an identical probability distribution over time, which implies that information in the past cannot be utilized to forecast future stock price movements (Fama, 1965). These assumptions make up the theoretical foundation on which the weak-form efficient market hypothesis is based.

In recent times, a lot of controversies have been instigating considering the efficacy of the weak-form efficient market hypothesis due to widely contradicting test results in both developed and emerging stock markets.

Most of the earliest research on testing for weak-form efficiency in mature capital markets validates the theory (Fama, 1965), whereas more recent studies state the opposite that stock market returns show signs of predictability (Lo and MacKinaly, 1988). The empirical results in the emerging markets are also highly conflicting, where some researchers have found evidence denying the random walk hypothesis in stock returns and others accept it.

1.2 Purpose and Research Questions

This paper aims to examine if China's two most prominent stock exchanges in Shanghai and Shenzhen exhibit signs of weak-form efficiency throughout the period 1992 to 2015. Consequently, the study attempts to find evidence of predictability in Chinese stock returns. A set of statistical tests such as autocorrelation test, runs test and variance ratio test are applied to daily share price data for six different indices to study the market efficiency. Furthermore, any tendencies toward increased efficiency over time is examined to track the overall development of the Chinese stock market. Our final aim is to investigate if stock market returns in both Chinese markets exhibit any seasonal anomalies depending on the day of the week. To summarize, the questions this paper aims to answer are the following:

- Does the Chinese stock market follow a random walk model and hence could it be considered weak-form efficient?
- Does the Chinese stock market exhibit tendencies toward increased efficiency over time?
- Are there any seasonal anomalies depending on the day of the week?

Given the above stated questions, the examined hypothesis is the following:

H_0 : *The Chinese stock market exhibit characteristics of a random walk*
H_1 : *The Chinese stock market does not exhibit any characteristics of a random walk*

Moreover, the daily calendar effect is tested through an ordinary least square (OLS) regression model, which is explained in greater detail later on. The additional hypothesis that is examined is:

H_0 : *Returns do not vary depending on the day of the week*
H_1 : *Returns vary depending on the day of the week*

The different statistical techniques utilized to test the random walk hypothesis are applied on the full sample as well as three sub-samples while the calendar effect is only tested for the full sample.

1.3 Delimitation

This study focuses primarily on market efficiency. Given the scope of the subject, we have limited our research only to include the weak form efficient market hypothesis and predictability in stock market returns. The statistical techniques utilized in this study disregard all technical trading rules traditionally employed to forecast future stock prices by analysts.

A large number of previously conducted studies have noted that inefficiency in the Chinese stock market might be the result of thin trading, which could imply significant bias. A greater time span compared to previous studies is used to reduce the impact of potential bias in our study.

2 | Theory and Literature Review

2.1 The Chinese Stock Market

China's real gross domestic product growth has been averaging about 10 percent a year ever since the economic reforms were introduced in 1978. As a result, China's financial, industrial as well as agricultural sectors have been drastically remodeled. The following establishment of two official stock markets in the early 1990s, the Shenzhen and Shanghai securities exchanges, played an intricate part in the early development of the Chinese stock market. The primary difference between these two exchanges is characterized by the listed companies on each exchange; large state-owned companies are listed on the Shanghai market while subsidiary companies are typically traded on the Shenzhen market. Both exchanges offer two different classes of shares, namely A-shares and B-shares (The World Bank Group, 2005).

Before the establishment of the Chinese Securities Regulatory Commission (CSRC) in 1992, the Chinese stock market was exclusively governed by the central bank. The shift in governance leads to a series of structural reforms throughout the years. In 1993, the Central People's Government published guidelines for issuance and trading of stocks, followed by the enactment of the Company Law and Rules on Administration of Securities Exchange the succeeding year. In 1999, the Security Law was passed, granting the CSRC authority to implement regulation of the national securities market. As a result, several reforms with the purpose of improving market efficiency were implemented, such as the introduction of non-tradable shares, enhancement of listed companies, remodeling of securities firms and revised share issuance procedure (Feng, 2015).

China's entry into the World Trade Organization (WTO) in 2001 sparked a significant amount of interest in the B-share markets amongst domestic investors. The incentives to trade in foreign currencies lead to an accelerated rate of market integration between A- and B- shares, as well as international markets.

Bearing in mind the tremendous growth and intensive development the Chinese security markets have undergone over the past years, there is still extensive work that needs to be done to call it a genuinely stable and mature market (Stock Market Handbook Editorial Board, 2008).

2.2 Efficient Market Hypothesis

Ever since Fama revised the efficient market hypothesis in the early 1970s, it has been a subject of considerable discussion within the field of financial economics. Market efficiency is obtained if all the available information is adequately incorporated in the pricing of an asset at each moment in time. According to Fama (1970), efficiency implies that prices on the market act like signals to accurately allocate resources, thus enabling an efficient market.

Certain conditions need to be met to achieve a fully efficient capital market. Firstly, there cannot be any transaction costs or any other expenses present in the market. Secondly, all relevant information relating to the pricing of assets should be readily available and completely free of charge. Lastly, the current price of an asset should "fully reflect" all available information Fama (1970).

Testing of the efficient market hypothesis is made possible only when the utilized dataset is specified. Hence, Fama introduced three different tests relating to separate subsets of information (Fama, 1970, 1991). The weak-form test, which uses historical security prices and other observable variables. The semi-strong form test, which includes previously mentioned information as well as any other publicly available information. Further, the strong form test, which comprises of both datasets above with the inclusion of private information. Fama (1991) later shifted the focus from the weak, semi-strong and strong form efficiency and regarded the theories henceforth as the test for return predictability, event studies, and test of private information, respectively.

2.3 Random Walk Hypothesis

According to Fama (1970), a market could be considered a random walk if the consecutive changes in individual security prices are independent. Given independent price changes and the absence of transaction costs, any artificially constructed trading strategy will not be able to outperform the market due to the unpredictable nature of future price movements. The concept of anticipated price movements being unpredictable is compatible with the random walk hypothesis, which suggests that the pattern generated by stock price movements are indistinguishable from a random walk pattern (Fama, 1965). Even though a random walk does not completely mimic the behavior of actual asset prices, the dependence structure might be insignificant enough actually to accept it as a reasonable approximation of actual stock price movements (Fama, 1965). Hence, by studying the random walk hypothesis, the weak-form efficient market hypothesis is examined simultaneously.

Denote the log-price process$X_t \equiv lnP_t$, where P_t is the stock price at time t. The general formulation of the random walk model suggests that if the expected value of a log-price process X_t is constant compared to its previous value X_{t-1} at time $t-1$, then the process is considered random. Thus, a stochastic process exhibits the characteristics of a random walk if

$$X_t = \mu + X_{t-1} + \epsilon_t, \tag{2.1}$$

where μ is the arbitrary drift parameter and ϵ_t is the independent and identically distributed disturbance term (Lo and MacKinaly, 2008). Consequently, if stock prices were to resemble a random walk, then the stock market would be considered weak-form efficient.

2.4 Literature Review

Fifield and Jetty (2008) tested the efficiency of the Chinese A-share and B-share markets after the regulatory reform which introduced domestic investors to the B-share market. The Chinese stock market efficiency was determined by using non-parametric ranks based variance-ratio tests along with the standard parametric variance tests. The authors used individual data on a company level to circumvent distortion, which usually is present in datasets based on index data. The said methods were applied to 370 shares over the time span ranging from 1996 to 2005. Fifield and Jetty concluded that A-shares tended to be more efficient than B-shares. Nonetheless, both markets have seen improvements concerning efficiency following the reform. The results indicate that the Chinese stock market suffers from information asymmetry. However, the inclusion of domestic investors into the B-share market has influenced the pricing efficiency positively and as a result increased the rate with which information is diffused amongst foreign investors

A similar study was carried out by (Hung, 2009), who examined whether the A- and B-share markets on the Shanghai and Shenzhen exchanges are weak-form efficient. The author also studied the effects of the relaxation of investment restrictions on B-share markets regarding efficiency. These two aspects were tested using both single and multiple variance ratio tests, which combines various methods such as LOMAC, CHODE, and Wright. The study concluded that A-shares on the Shanghai exchange exhibited a greater degree of efficiency compared to the rest of the shares. Regarding the sub-sample periods, all stock indices on both exchanges showed signs of increasing weak-form efficiency following the regulatory reform, except Shanghai A-shares. The improved market efficiency generated by the deregulation and liberalization policies is the result of an increase in liquidity and maturity of the Chinese stock market.

Charles and Darné (2009)) also examined the weak-form efficiency of the Shanghai and Shenzhen stock markets for A- and B-shares using both new and conventional multiple variance ratio tests. In particular, the Whang-Kim's sub-sampling test, Kim's bootstrap test, and Chow-Denning test were utilized. Furthermore, the authors investigated the impact on the Chinese stock market efficiency following the changes in relationship structures between banks and the stock exchange as well as the regulatory reform concerning the inclusion of domestic investors into B-share markets. The generated results suggest that A- shares tend to be more efficient than B-shares, which implies that liquidity, market capitalization, and information asymmetry might be significant factors in describing the weak-form efficiency. B-shares for the Chinese stock exchange did not follow the general principals of a random walk and are therefore considered significantly inefficient. However, the inclusion of domestic investors in the B-share markets has had a positive effect on the B-share market efficiency.

Gao and Kling (2005) conducted a study on calendar effects in the Chinese stock markets, where the main focus was on the daily and monthly effects. The authors observed considerable daily and monthly calendar effects in both the Shanghai and Shenzhen markets employing return series for each stock. Gao and Kling argued that these effects might be related to two unique features of the Chinese stock market. In China, the end of the year usually occurs around February, which implies that any seasonal anomalies cannot be expected in January. Also, the need for tax-loss selling is non-existent due to capital gains being relieved from taxes. The generated results suggest a significant year effect in 1991, which gradually diminished over time. Furthermore, the authors claim that the highest returns are observed in March and April as a result of the Chinese year-end occurring in February. Regarding the daily effects, they found a striking discovery suggesting that Fridays exhibit signs of profitability and Mondays are significantly weaker compared to other weekdays.

3 | Data and Methodology

3.1 Data Description

The data used consist of daily price indices for the Shanghai and the Shenzhen market. The indices of interest are the A- and B-share indices, as well as the Composite index for both markets. All of these indices represent a weighted average of the daily prices listed on each stock exchange. The data is gathered from Thomson Reuters Datastream, where the observed period ranges from 1992 to 2015. The Shanghai market indices were chosen from February 21, 1992, to December 10, 2015, whereas the Shenzhen market indices span the period from October 5, 1992, to December 10, 2015.

Furthermore, the sampling period was split into different sub-periods to isolate the impact of certain events that might have affected the Chinese stock market efficiency. The highlighted events associated with various structural reforms are the following:

1. February 21, 1992, to December 29, 1995, represent the early development of the Chinese stock market and underline the effects of various reforms imposed by the CSRC.

2. January 1, 1996, to December 29, 2006, highlight a period in which the Chinese stock market underwent tremendous growth and CSRC's attempts to mitigate market fluctuations.

3. January 1, 2007, to December 31, 2012, covers the global financial crisis as well as the aftermath.

4. January 1, 2013, to December 10, 2015, highlight the events leading up the Chinese stock market crash and the most recent time frame.

The daily market returns were utilized as the primary variable to conduct the various statistical tests. The returns r_t for each share were obtained using the daily index values accordingly:

$$r_t = ln\left(\frac{P_t}{P_{t-1}}\right), \tag{3.1}$$

where P_t and P_{t-1} indicate the closing prices at time t and $t-1$, respectively and ln is the natural logarithm (Brooks, 2004).

3.2 Autocorrelation Test

The autocorrelation test examines the correlation between a set of returns at a given point in time and lagged returns within the same set. The test suggests that if the correlation coefficients are significantly different from zero, then the Chinese stock market returns might exhibit tendencies toward serial dependency.

The model for the correlation coefficient is defined as

$$\rho(k) = \frac{Cov(r_t, r_{t-k})}{\sqrt{Var(r_t)}\sqrt{Var(r_{t-k})}} = \frac{Cov(r_t, r_{t-k})}{Var(r_t)}, \tag{3.2}$$

where $\rho(k)$ is the autocorrelation coefficient of the return series r_t at time t and k represents the lag of the given period.

According to Fuller (1976), the sample correlation coefficients $\hat{\rho}$ assumed to be asymptotically independent, normally distributed with a zero mean and the standard deviation of

$$\sigma(\hat{\rho}(k) = \sqrt{\frac{1}{n-k}}, \tag{3.3}$$

where n represent the number of observations and k is the lag for the period.

To examine the joint hypothesis that all the autocorrelations are significantly different from zero, the Ljung-Box Q-test (Ljung and Box, 1978) is applied. The test statistic is defined as

$$Q = n(n+2)\sum_{k=1}^{m}\frac{\hat{\rho}^2(k)}{(n-k)}, \tag{3.4}$$

where n denote the sample size, m is the number of autocorrelation lags, and $\rho(k)$ is the sample correlation coefficient at lag k. Under the null hypothesis, the distribution of Q with m-degrees of freedom follows a chi-square.

3.3 Runs Test

The run test is a non-parametric test technique that is widely used to examine serial dependency in share price movements. The test makes use of the assumption that a series of data is considered random if the observed number of runs are approximately equal to the expected number of runs.

The informal definition of a run is a sequence of successive price changes with a fixed sign. The runs test is performed through comparison of the actual number of runs R with the expected number or runs M, which is computed as

$$M = \frac{n(n+1) - \sum_{i=1}^{3} \eta_i^2}{n}, \tag{3.5}$$

where n represent the number of observations, i denote the different signs plus, minus and fixed, respectively, and η_i is the number of changes within each sign category.

The number of runs m assumes approximately the a normal distribution for large observation sets with the standard deviation of runs defined as

$$\sigma_M = \left[\frac{\sum_{i=1}^{3} \eta_i^2 \left[\sum_{i=1}^{3} \eta_i^2 + n(n+1) \right] - 2n \sum_{i=1}^{3} \eta_i^3 - n^3}{n^2 (n-1)} \right]^{1/2}. \tag{3.6}$$

The normally distributed Z-statistic of the actual number of runs R is computed as

$$Z = \frac{R - M \pm ({}^1/_2)}{\sigma_M}, \tag{3.7}$$

where ${}^1/_2$ represent the correction factor for continuity adjustments (Wallis and Roberts, 1963). The continuity adjustment adopts a positive sign for for $R \leq M$ and a negative for $R \geq M$, which alters the value of Z accordingly. Note that the sign of Z is inversely related to the autocorrelation, where a negative value of Z signifies a positive autocorrelation and vice versa. Consequently, a positive autocorrelation suggests the presence of positive dependence amongst stock prices, which violates the assumptions of the random walk hypothesis.

3.4 Variance Ratio Test

The variance ratio test was initially introduced by Lo and MacKinaly (1988) and utilizes the property that the variance in a random walk X_t has linear increments in its sampling interval. If a series of returns were to be considered random, then the variance ratio of the qth difference would be $^1/_q$ times the variance ratio for the first difference. Hence, the random walk hypothesis can be examined by comparing the variance of $X_t - X_{t-q}$ to q times the variance of $X_t - X_{t-1}$.

Assume that P_t represents the stock price at time t and that a random walk series X_t is defined as the log-price process $X_t \equiv lnP_t$. The variance ratio is then defined as

$$VR(q) = \frac{Var(q)}{Var(1)}, \tag{3.8}$$

where $Var(q)$ is the variance of $X_t - X_{t-q}$ and $Var(1)$ is q times the variance of $X_t - X_{t-1}$.

The variances of the first and qth difference, $Var(1)$ and $Var(q)$, respectively are computed as

$$\begin{aligned} Var(1) &= \frac{1}{nq-1}\sum_{t=1}^{nq}\left(X_t - X_{t-1} - \hat{\mu}\right)^2 \\ Var(q) &= \frac{1}{m}\sum_{t=q}^{nq}\left(X_t - X_{t-q} - q\hat{\mu}\right)^2, \end{aligned} \tag{3.9}$$

where the average return $\hat{\mu}$ as well as the constant m are defined as

$$\hat{\mu} = \frac{1}{nq}\sum_{t=1}^{nq}\left(X_t - X_{t-1}\right) = \frac{1}{nq}\left(X_{nq} - X_0\right) \tag{3.10}$$

and

$$m = q\left(nq - q + 1\right)\left(1 - \frac{q}{nq}\right). \tag{3.11}$$

The standard normally distributed test statistic under the assumption of homoscedasticity is defined as

$$Z(q) = \frac{VR(q) - 1}{\Phi(q)^{1/2}}, \tag{3.12}$$

with the asymptotic variance given by

$$\Phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)}, \tag{3.13}$$

where nq represents the total number of observations.

The test statistic above is then modified to accommodate for heteroscedasticity, which culminated in the heteroscedasticity-consistent $Z^*(q)$ defined as

$$Z^*(q) = \frac{VR(q) - 1}{\Phi^*(q)^{1/2}}, \tag{3.14}$$

which also is standard normally distributed with the corresponding asymptotic variance given by

$$\Phi^*(q) = \sum_{j=1}^{q-1} \left[\frac{2(q-j)}{q} \right]^2 \hat{\delta}(j), \tag{3.15}$$

where the heteroscedasticity-consistent estimator is denoted as

$$\hat{\delta}(j) = \frac{\sum_{t=j+1}^{nq} \left(X_t - X_{t-1} - \hat{\mu}\right)^2 \left(X_{t-j} - X_{t-j-1} - \hat{\mu}\right)^2}{\left[\sum_{t=1}^{nq} \left(X_t - X_{t-1} - \hat{\mu}\right)^2 \right]^2}. \tag{3.16}$$

The null hypothesis states that $V(q)$ is not statistically different from one. However, if the random walk model is rejected under the assumption of heteroscedasticity, then there is confirmation of autocorrelation present within the return series. Moreover, the generated $V(q)$ show signs of negative serial correlation for values less than one, while for values exceeding one signify a positive serial correlation. Thus, the returns exhibit evidence of predictability if $VR(q)$ is greater than one.

3.5 Daily Calendar Effect

The most striking examples that contradict the random walk in mature capital markets are related to individual calendar events, such as weekends and holidays. Most researches have focused on day of the week effect, where several of these have identified a so-called weekend effect. By examining the daily calendar effects of the Chinese stock market, the grasp of the weak-form efficient market hypothesis is extended.

The study is carried out in a similar fashion to previous analyses, where a regression is performed for the entire period to test for the existence of any statistically significant anomalies between index returns on different weekdays. The regression model is defined as

$$R_t = b_1 D_{1t} + b_2 D_{2t} + b_3 D_{3t} + b_4 D_{4t} + b_5 D_{5t} + \epsilon_t,$$

where R_t and ϵ_t denote the return and the random error term, respectively, at time t. The variables D_{1t} to D_{5t} represent dummy variables, which adopt the value 1 or 0 depending on the day of the week. Consequently, b_1 to b_5 are the ordinary least square coefficients, which represent the average returns for each weekday. The indices 1 to 5 indicate the days Monday through Friday.

The tested hypothesis is defined as

$$H_0 : b_1 = b_2 = b_3 = b_4 = b_5.$$

The absence of a daily calendar effect in average returns implies that the coefficients b_1 to b_5 are not significantly different from zero. If the hypothesis were to be rejected, the implication would be that at least one of the average daily returns is not equal. This assumption is tested through F-statistics, where the coefficients b1 through b5 would have to be identical to accept the null hypothesis. Thus, the daily calendar effect is verified when no less than one of the coefficients corresponding to a dummy variable is statistically significant. If a daily calendar effect is observed then Chinese stock market returns might not be entirely random (Brooks, 2004).

4 | Results

4.1 Descriptive Statistics

The summarized descriptive statistics are from both Shanghai and Shenzhen return series spanning the full sample period from 1992 to 2015 is illustrated in Table 4.1. According to Table 4.1, all the indices exhibit positive mean returns. The Shanghai A-share and B-share indices have the highest and the lowest mean returns of 0.0375 and 0.0183, respectively. The lowest minimum returns are observed in the Shenzhen A-share index, whereas the highest maximum returns are found in the Shanghai A-share. Concerning the standard deviation of returns ranging from 1.979 to 2.442, the least volatile indices are the Shanghai and the Shenzhen B-share while the most volatile index is the Shanghai Composite. In essence, Shenzhen indices exhibit a lesser degree of volatility in comparison to its Shanghai equivalent, but the returns are notably greater in the Shanghai market.

Furthermore, according to Table 4.1 the skewness values suggest that the returns of all the indices differ from the standard normal distribution and that they are significantly skewed to the right. This implies a greater likelihood of increases in returns rather than decreases. Moreover, the highest and lowest positive value of skewness are observed for both A-shares and B-shares, respectively, of the Shanghai market.

Regarding the excess kurtosis values, which are considerably large for all indices, spanning values from 8.7391 to 158.62 for the Shanghai B-share and A-share, respectively. Taking into consideration that the kurtosis of any univariate normal distribution is 3, the generated results are clearly leptokurtic, which is similar to the findings of Fifield and Jetty (2008). Also, the significantly positive results suggest that the distribution of return series are highly centered.

Table 4.1: Descriptive statistics of the continuously compounded daily stock returns for both Shanghai and Shenzhen market.

	Shanghai			Shenzhen		
	A Index	B Index	Composite	A Index	B Index	Composite
N	6209	6209	6209	6048	6048	6048
Mean	0.037561	0.018355	0.036443	0.034702	0.035953	0.034762
Std. Dev	2.4425	2.1003	2.3657	2.1476	1.9796	2.0943
Max	74.517	13.822	71.915	29.578	13.798	27.215
Min	-18.427	-13.716	-17.905	-19.632	-16.699	-18.883
Skewness	5.5606	0.0884	5.3707	0.50955	0.13162	0.37923
Kurtosis	158.62	8.7391	154.27	18.456	10.744	16.624

Note: N denotes the number of observations. The mean, standard deviation, max, and min are denoted in percent. The calculations are given for the entire sample period ranging from 1992 to 2015.

4.2 Autocorrelation

The results of the Ljung-Box Q-statistics test for the full period as well as the four sub-periods is provided in Table 4.2. The log returns for both the Shanghai and the Shenzhen indices are autocorrelated in the full sample period and period E. Thus the null hypothesis of no autocorrelation for all returns on both Shanghai and Shenzhen indices is rejected at 1% significance level for the lags 1 through 12.

Table 4.2: Results of the Ljung-Box Q-statistics for the full sample period

	Shanghai			Shenzhen		
	A Index	B Index	Composite	A Index	B Index	Composite
			A: Full Period			
Q(1)	***9.8989	***131.2226	***9.7347	***9.0612	***98.1028	***11.0575
Q(2)	***14.4881	***131.8519	***14.0692	***10.4182	***99.3278	***11.9386
Q(3)	***26.1352	***138.8256	***24.2683	***16.5632	***125.5965	***19.0769
Q(4)	***36.3354	***142.3097	***33.4985	***40.2375	***153.3393	***44.3887
Q(6)	***43.8745	***145.3415	***40.0371	***51.0539	***156.3383	***53.8285
Q(12)	***69.1303	***158.2655	***62.5233	***57.7375	***176.7392	***61.1585

Note: Q(1) and Q(12) represent the Ljung-Box statistic signifying the presence of first- and twelfth-order autocorrelation. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

In period B (see Table 4.3), all of the indices exhibit tendencies of autocorrelation at various significance levels, except for the Shenzhen A-share and Composite indices. Consequently, the autocorrelation for these indices is insignificant at lags 1 through 3.

Table 4.3: Results of the Ljung-Box Q-statistics for the period ranging from 1992 to 1995

	Shanghai			**Shenzhen**		
	A Index	B Index	Composite	A Index	B Index	Composite
			B: 02/1992-02/1995			
Q(1)	*3.6153	***77.0319	*3.6955	0.0382	***68.6054	0.1401
Q(2)	**6.9476	***80.1859	**7.2172	1.5837	***95.1895	1.5708
Q(3)	**8.4246	***81.1974	**8.3515	2.2872	***101.7831	2.0341
Q(4)	**9.8775	***81.4188	**9.4996	**11.0449	***118.1195	**10.5907
Q(6)	*11.7019	***83.1186	*10.9961	***16.8384	***123.0904	***17.0464
Q(12)	*20.5629	***95.9299	*19.3265	**25.0660	***130.7091	**24.0385

Note: Q(1) and Q(12) represent the Ljung-Box statistic signifying the presence of first- and twelfth-order autocorrelation. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

In the following period C (see Table 4.4), the Shanghai and Shenzhen B-share index are the only indices that are autocorrelated at all given lags. The A-Share and Composite indices for both Shanghai and Shenzhen are statistically insignificant at lags 1 and 2.

Table 4.4: Results of the Ljung-Box Q-statistics for the period ranging from 1996 to 2006

	Shanghai			**Shenzhen**		
	A Index	B Index	Composite	A Index	B Index	Composite
			C: 01/1996-12/2006			
Q(1)	0.0114	***52.1912	0.0001	1.2834	***48.7155	1.6632
Q(2)	0.1511	***52.3365	0.1215	2.4175	***49.2840	2.4192
Q(3)	***14.4849	***57.7857	***13.9707	***21.2713	***70.4744	***19.7401
Q(4)	***15.2385	***58.5866	***14.8242	***24.6221	***84.5103	***25.8651
Q(6)	***17.5339	***58.7291	**16.7262	***26.9743	***86.3367	***26.7295
Q(12)	***37.4543	***67.8988	***36.3896	***42.3401	***99.2598	***41.2280

Note: Q(1) and Q(12) represent the Ljung-Box statistic signifying the presence of first- and twelfth-order autocorrelation. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

Moreover, in period D (see Table 4.5) the indices for Shenzhen markets are all correlated except for the B-share index, where the autocorrelation is insignificant at lag 12. The Shanghai market, on the other hand, exhibit only one autocorrelated index at all of the given lags, namely the Shanghai B-share. Both the A-share index and the Composite index of the Shanghai market are insignificant at lags 1 through 3, as well as 12.

Table 4.5: Results of the Ljung-Box Q-statistics for the period ranging from 2007 to 2012

	Shanghai			Shenzhen		
	A Index	B Index	Composite	A Index	B Index	Composite
			D: 01/2007-12/2012			
Q(1)	0.6494	***10.2017	0.6413	***6.6274	**5.9225	**6.4143
Q(2)	0.8120	***10.5294	0.8053	**7.0619	**6.0916	**6.8725
Q(3)	5.3946	***14.0345	5.4057	***12.6545	*7.6977	***12.3486
Q(4)	**9.8523	***17.7177	**9.8959	***16.2794	**11.9787	***15.9348
Q(6)	*11.8891	***21.2297	*11.8942	***19.2834	**12.8876	***18.9224
Q(12)	15.6871	***29.1476	15.6996	**24.9420	16.3091	**24.5867

Note: Q(1) and Q(12) represent the Ljung-Box statistic signifying the presence of first- and twelfth-order autocorrelation. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

In the most recent period E (see Table 4.6), all the indices in both markets are autocorrelated, thus implying that all the indices are statistically significant at the 1% level at all given lags.

Table 4.6: Results of the Ljung-Box Q-statistics for the period ranging from 2013 to 2015

	Shanghai			Shenzhen		
	A Index	B Index	Composite	A Index	B Index	Composite
			E: 01/2013-12/2015			
Q(1)	***12.1774	***31.8683	***12.2047	***16.7172	***20.8404	***16.7588
Q(2)	***17.5867	***40.8379	***17.6379	***17.7548	***26.1377	***17.8067
Q(3)	***18.4457	***43.9261	***18.4997	***17.9424	***28.8322	***17.9898
Q(4)	***29.1839	***43.9292	***29.2292	***19.0033	***28.8608	***19.0541
Q(6)	***35.8018	***48.9141	***35.8540	***19.6917	***31.1652	***19.7622
Q(12)	***57.8555	***94.9955	***58.0727	***44.5862	***50.3635	***44.8194

Note: Q(1) and Q(12) represent the Ljung-Box statistic signifying the presence of first- and twelfth-order autocorrelation. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

Overall, the findings suggest that the return series for both the Shanghai and the Shenzhen market throughout the whole period exhibit evidence of predictability. This observation is most evident in the B-share market, where the results from the Q-statistics consistently reject the null hypothesis for each period. The Shanghai market shows signs of increasing efficiency between periods C and D, where the A-share and Composite indices are statistically insignificant at lags 1 through 3. Similar results are found for A-share and Composite indices between periods B and C for the Shenzhen market. However, both markets show tendencies of increasing inefficiency over time.

4.3 Runs Test

The generated results from the runs test on indices for the Shanghai and Shenzhen markets are presented in Table 4.7. According to the results for the whole period, the runs test indicate that both Shanghai and Shenzhen markets are not weak-form efficient, which is verified by the Z-values for all indices at 1% significance level. The negative signs on the Z-values are explained by the number of runs being less than the expected number of runs under the assumption of independent returns. Hence, the result underlines the presence of positive serial autocorrelation, which is supported of by the results generated from the serial correlation tests.

Table 4.7: The results generated from the runs tests for each index of the Shanghai and Shenzhen market spanning the full period

Time Series	**Number of runs**	**Above mean**	**Below mean**	**Z-stat**	***p*-value**
		A: Full period			
Shanghai					
A Index	2976	2937	3272	-3.0540	0.0023
B Index	2758	2862	3347	-8.3784	0.0000
Composite	2982	2929	3280	-2.8796	0.0040
Shenzhen					
A Index	2773	2945	3103	-6.4197	0.0000
B Index	2669	2763	3285	-8.6281	0.0000
Composite	2747	2923	3125	-7.0582	0.0000

Note: The number of runs measures the degree of randomness, while below and above signify the number of observations less than and greater or equal to the mean. The Z-value and the *p*-value denote the Z-statistics and the corresponding probability, respectively.

For period B (see Table 4.8), the Z-values for the returns on B-share indices of the Shanghai and Shenzhen market are the only indices in the period that are significant at the 1% level. All other indices are highly insignificant.

Table 4.8: The results generated from the runs tests for each index of the Shanghai and Shenzhen market spanning the period 1992-1995

Time Series	Number of runs	Above mean	Below mean	Z-stat	p-value
		B: 02/1992-02/1995			
Shanghai					
A Index	502	457	548	0.1349	0.8926
B Index	428	505	500	-4.7333	0.0000
Composite	506	452	553	0.4511	0.6518
Shenzhen					
A Index	418	410	434	-0.2867	0.7744
B Index	356	446	398	-4.5013	0.0000
Composite	422	409	435	-0.0069	0.9945

Note: The number of runs measures the degree of randomness, while below and above signify the number of observations less than and greater or equal to the mean. The Z-value and the p-value denote the Z-statistics and the corresponding probability, respectively.

The following period C (see Table 4.9) exhibit significant Z-values for all of the indices in both Shanghai and Shenzhen markets, where all of the Shenzhen indices, as well as the Shanghai B-share index, are significant at the 1% level. Also, the Shanghai A-share and Composite indices are significant at the 5% level.

Table 4.9: The results generated from the runs tests for each index of the Shanghai and Shenzhen market spanning the period 1996-2006

Time Series	Number of runs	Above mean	Below mean	Z-stat	p-value
		C: 01/1996-12/2006			
Shanghai					
A Index	1364	1318	1551	-2.3135	0.0207
B Index	1299	1235	1634	-4.1226	0.0000
Composite	1358	1318	1551	-2.5390	0.0111
Shenzhen					
A Index	1318	1368	1501	-4.2635	0.0000
B Index	1290	1250	1619	-4.6051	0.0000
Composite	1298	1362	1507	-4.9923	0.0000

Note: The number of runs measures the degree of randomness, while below and above signify the number of observations less than and greater or equal to the mean. The Z-value and the p-value denote the Z-statistics and the corresponding probability, respectively.

Furthermore, in period D (see Table 4.10) the Z-statistics indicate yet again that all of the indices in the Shenzhen market are significant at the 1% level, similar to results in period C. However, the difference is observed in the Shanghai market, where the A-share and Composite indices are now statistically insignificant.

Table 4.10: The results generated from the runs tests for each index of the Shanghai and Shenzhen market spanning the period 2007-2012

Time Series	**Number of runs**	**Above mean**	**Below mean**	**Z-stat**	***p*-value**
D: 01/2007-12/2012					
Shanghai					
A Index	741	884	681	-1.4832	0.1382
B Index	718	793	772	-3.2807	0.0010
Composite	739	885	680	-1.5732	0.1158
Shenzhen					
A Index	698	802	763	-4.2767	0.0000
B Index	708	788	777	-3.7911	0.0001
Composite	698	798	767	-4.2848	0.0000

Note: The number of runs measures the degree of randomness, while below and above signify the number of observations less than and greater or equal to the mean. The Z-value and the *p*-value denote the Z-statistics and the corresponding probability, respectively.

In the most recent period E (see Table 4.11), the estimated Z-values for the returns on the Shanghai and Shenzhen market are all significant at 1% significance level, except for the Shenzhen B-share index, which is insignificant.

Table 4.11: The results generated from the runs tests for each index of the Shanghai and Shenzhen market spanning the period 2013-2015

Time Series	**Number of runs**	**Above mean**	**Below mean**	**Z-stat**	***p*-value**
E: 01/2013-12/2015					
Shanghai					
A Index	341	365	402	-3.0499	0.0023
B Index	342	380	387	-3.0330	0.0024
Composite	347	369	398	-2.6379	0.0083
Shenzhen					
A Index	345	395	372	-2.7959	0.0051
B Index	351	379	388	-2.3812	0.0172
Composite	345	395	372	-2.7959	0.0051

Note: The number of runs measures the degree of randomness, while below and above signify the number of observations less than and greater or equal to the mean. The Z-value and the *p*-value denote the Z-statistics and the corresponding probability, respectively.

The results from the runs test bear slight similarities with those from the serial correlation test. For instance, the test statistics for B-share indices are greater than those for A-share indices in both the Shanghai and the Shenzhen market. Moreover, the runs test support the notion of possible predictability in both markets for the full period, which is consistent with the results generated from the Ljung-Box Q-tests.

However, the differences between the serial correlation test and the runs test are primarily observed in period B, and C. The runs test in period B indicate that A-share indices and Composite indices are insignificant for both markets, which according to the autocorrelation test is valid only for the Shenzhen market. A similar outcome is noted in period D, where the runs test indicate that the A-share and Composite indices are statistically significant for the Shanghai market only while the serial correlation test shows the same test results for both markets.

4.4 Variance Ratio

The results of the variance ratio tests for various lags are presented in Table 4.12 for both Shanghai and Shenzhen markets. For the full period, the Z(q) statistics for all indices in the Shanghai and Shenzhen markets are statistically significant at the 1% level. Thus, rejecting the null hypothesis of a random walk is well within reason. Nonetheless, under the assumption of heteroscedasticity, the null hypothesis is rejected for all indices except in two instances, the Shanghai A-share and Composite indices in interval two. This observation indicates that heteroscedasticity might be the underlying factor affecting the rejection of the null hypothesis of a random walk under homoscedasticity, which in turn renders it impossible to determine the individual contributions on the serial correlation in returns. Also, the variance ratio seems to be increasing with increasing lags, which is an indication of positive serial correlation.

Table 4.12: The results of the variance ratio tests for returns on indices for both Shanghai and Shenzhen markets throughout the full period

			Test intervals (q)				
Time Series	**N**		**2**	**4**	**8**	**12**	**16**
			A: Full Period				
Shanghai							
A Index	6209	VR(q)	1.0402	1.1097	1.2112	1.2308	1.2465
		Z(q)	***3.1715	***4.6210	***5.6263	***4.8504	***4.4126
		Z*(q)	1.4716	*1.9244	**2.2778	**2.0324	*1.9208
B Index	6209	VR(q)	1.1457	1.2247	1.3288	1.4062	1.4765
		Z(q)	***11.4814	***9.4623	***8.7585	***8.5380	***8.5310
		Z*(q)	***6.3253	***5.3886	***5.1436	***5.1745	***5.3211
Composite	6209	VR(q)	1.0399	1.1071	1.2012	1.2183	1.2355
		Z(q)	***3.1453	***4.5097	***5.3602	***4.5891	***4.2159
		Z*(q)	1.4935	*1.9399	**2.2422	**1.9868	*1.8973
Shenzhen							
A Index	6048	VR(q)	1.0390	1.0899	1.1803	1.1972	1.2264
		Z(q)	***3.0330	***3.7389	***4.7396	***4.0912	***4.0006
		Z*(q)	**1.7274	**1.9551	**2.4552	**2.1990	**2.2357
B Index	6048	VR(q)	1.1276	1.2392	1.4239	1.5413	1.6269
		Z(q)	***9.9269	***9.9447	***11.1452	***11.2285	***11.0752
		Z*(q)	***4.7570	***4.9613	***5.8207	***6.1039	***6.2002
Composite	6048	VR(q)	1.0431	1.0943	1.1848	1.2047	1.2364
		Z(q)	***3.3480	***3.9220	***4.8585	***4.2470	***4.1765
		Z*(q)	**1.9850	**2.1707	***2.6591	**2.4068	**2.4556

Note: VR(q) denote estimates of variance ratios. Z(q) and Z*(q) represent the asymptotic standard test statistics under homoscedasticity and heteroscedasticity, and q is the interval of the observations. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

For period B (see Table 4.13), the results indicate that all the Z(q) statistics in both markets reject the null hypothesis of a random walk, except for the Shenzhen A-share and Composite indices across all intervals. Rejection of the null hypothesis under heteroscedasticity is observed for B-share indices across all intervals for both the Shanghai and the Shenzhen market. This is also observed for the Shanghai A-share index, except interval two. The calculated variance ratios for all indices, not including the Shenzhen Composite index, are yet again increasing relative the interval length of q. The Shenzhen Composite index exhibit increasing values for Var(q) up to the 8th interval, where it diminishes as q continues to grow.

Table 4.13: The results of the variance ratio tests for returns on indices for both the Shanghai and the Shenzhen markets throughout the period 1992-1995

Time Series	**N**		**Test intervals (q)** 2	4	8	12	16
			B: 02/1992-02/1995				
Shanghai							
A Index	1005	VR(q)	1.0620	1.1732	1.3094	1.3560	1.3827
		Z(q)	**1.9655	***2.9344	***3.3163	***3.0104	***2.7564
		Z*(q)	1.4453	*1.9120	**2.0875	**1.9611	*1.8674
B Index	1005	VR(q)	1.2786	1.4863	1.6830	1.8404	2.0050
		Z(q)	***8.8317	***8.2409	***7.3203	***7.1063	***7.2384
		Z*(q)	***4.8411	***4.7494	***4.3205	***4.4157	***4.7252
Composite	1005	VR(q)	1.0627	1.1734	1.2989	1.3423	1.3713
		Z(q)	**1.9864	***2.9389	***3.2036	***2.8942	***2.6739
		Z*(q)	1.4523	*1.9187	**2.0190	*1.8877	*1.8156
Shenzhen							
A Index	844	VR(q)	1.0090	1.0457	1.1285	1.1189	1.1142
		Z(q)	0.2612	0.7094	1.2623	0.9215	0.7539
		Z*(q)	0.1846	0.4319	0.7473	0.5686	0.4877
B Index	844	VR(q)	1.2869	1.6584	2.1012	2.3276	2.5176
		Z(q)	***2.2050	***3.1487	***4.1040	***4.4870	***4.8341
		Z*(q)	**8.3357	***10.2238	***10.8155	***10.2879	***10.0161
Composite	844	VR(q)	1.0151	1.0561	1.1379	1.1292	1.1284
		Z(q)	0.4398	0.8705	1.3541	1.0015	0.8473
		Z*(q)	0.3087	0.5387	0.8157	0.6294	0.5584

Note: VR(q) denote estimates of variance ratios. Z(q) and Z*(q) represent the asymptotic standard test statistics under homoscedasticity and heteroscedasticity, and q is the interval of the observations. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

Period C (see Table 4.14) exhibit similar characteristics with previously mentioned periods, where the results of the Z(q) and Z*(q) statistics for both B-share indices suggest that the random walk hypothesis is rejected in all the given intervals. The returns of the Shanghai A-share and Composite indices exhibit a random walk pattern, whereas the results of Z(q) statistics for the same indices on the Shenzhen market indicate that the random walk hypothesis is rejected for all intervals except for interval two. Rejection of the random walk hypothesis under heteroscedasticity for the indices mentioned above of the Shenzhen market is valid for the intervals 8, 12, and 16. Regarding the variance ratios of index returns, all indices exhibit values of Var(q) greater than one across all intervals, with the exception of the Shanghai A-share and Composite indices in interval two.

Table 4.14: The results of the variance ratio tests for returns on indices for both Shanghai and Shenzhen markets throughout the period 1996-2006

			Test intervals (q)				
Time Series	**N**		**2**	**4**	**8**	**12**	**16**
			C: 01/1996-12/2006				
Shanghai							
A Index	2869	VR(q)	0.9968	1.0235	1.0718	1.0262	1.0151
		Z(q)	-0.1731	0.6716	1.2994	0.3738	0.1842
		Z*(q)	-0.0959	0.3733	0.7670	0.2324	0.1185
B Index	2869	VR(q)	1.1354	1.2180	1.2990	1.3540	1.4186
		Z(q)	***7.2519	***6.2409	***5.4135	***5.0582	***5.0936
		Z*(q)	***4.0460	***3.5961	***3.2202	***3.1183	***3.2432
Composite	2869	VR(q)	0.9987	1.0261	1.0757	1.0310	1.0210
		Z(q)	-0.0712	0.7478	1.3699	0.4426	0.255 9
		Z*(q)	-0.0395	0.4176	0.8128	0.2766	0.1655
Shenzhen							
A Index	2869	VR(q)	1.0211	1.0935	1.1997	1.2014	1.2417
		Z(q)	1.1310	***2.6783	***3.6169	***2.8771	***2.9407
		Z*(q)	0.6044	1.4554	**2.0492	*1.6964	*1.7907
B Index	2869	VR(q)	1.1309	1.2548	1.4630	1.6024	1.7011
		Z(q)	***7.0113	***7.2946	***8.3838	***8.6062	*** 8.5311
		Z*(q)	***3.5482	***3.8047	***4.5266	***4.8170	***4.9063
Composite	2869	VR(q)	1.0241	1.0927	1.1996	1.2057	1.2464
		Z(q)	1.2897	***2.6532	***3.6140	***2.9393	***2.9985
		Z*(q)	0.7541	1.5683	**2.1801	*1.8266	*1.9127

Note: VR(q) denote estimates of variance ratios. Z(q) and Z*(q) represent the asymptotic standard test statistics under homoscedasticity and heteroscedasticity, and q is the interval of the observations. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

Regarding period D (see Table 4.15), the Z(q) and Z*(q) statistics reject the null hypothesis for the Shenzhen A-share and Composite indices, as well as the Shanghai B-share index. The rest of the indices of the Shanghai market, namely the A-share and Composite, fail to reject random walk hypothesis. Moreover, the Shenzhen B-share index rejects the random walk hypothesis in all intervals under homoscedasticity, while under the assumption of heteroscedasticity rejection only occurs in interval 2, 4 and 8.

Table 4.15: The results of the variance ratio tests for returns on indices for both Shanghai and Shenzhen markets throughout the period 2007-2012

			Test intervals (q)				
Time Series	**N**		**2**	**4**	**8**	**12**	**16**
			D: 01/2007-12/2012				
Shanghai							
A Index	1565	VR(q)	0.9807	0.9892	1.0534	1.0599	1.0863
		Z(q)	-0.7653	-0.2276	0.7146	0.6325	0.7756
		Z*(q)	-0.5757	-0.1775	0.5642	0.5030	0.6202
B Index	1565	VR(q)	1.0820	1.1342	1.2628	1.3139	1.3449
		Z(q)	***3.2455	***2.8375	***3.5145	***3.3123	***3.0993
		Z*(q)	**2.0196	*1.8087	**2.2940	**2.1952	**2.0851
Composite	1586	VR(q)	0.9808	0.9894	1.0542	1.0613	1.0877
		Z(q)	-0.7601	-0.2233	0.7250	0.6471	0.7885
		Z*(q)	-0.5715	-0.1741	0.5720	0.5144	0.6303
Shenzhen							
A Index	1565	VR(q)	1.0663	1.1147	1.1867	1.2165	1.2674
		Z(q)	***2.6234	**2.4263	**2.4975	**2.2844	**2.4036
		Z*(q)	**2.0328	*1.9245	**2.0093	*1.8562	**1.9691
B Index	1565	VR(q)	1.0624	1.0997	1.1777	1.1895	1.1999
		Z(q)	**2.4691	***2.1087	**2.3761	**1.9998	*1.7962
		Z*(q)	*1.7887	**1.5612	***1.8014	1.5529	1.4204
Composite	1565	VR(q)	1.0653	1.1124	1.1833	1.2122	1.2622
		Z(q)	***2.5816	**2.3763	**2.4509	**2.2391	**2.3569
		Z*(q)	**2.0041	*1.8875	**1.9743	*1.8217	*1.9333

Note: VR(q) denote estimates of variance ratios. Z(q) and Z*(q) represent the asymptotic standard test statistics under homoscedasticity and heteroscedasticity, and q is the interval of the observations. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

In the most recent period E (see Table 4.16), the results of Z(q) and Z*(q) statistics rejects the null hypothesis for the Shenzhen A-share and Composite indices. For the Shenzhen B-share index, the result is identical to the one found in period D. Conversely, the results observed in the Shanghai market are rather varied, where most of the indices exhibit a random walk pattern for intervals 4 through 16. The only exceptions in the Shanghai market are the B-share index in the entire interval and the A-share as well as the Composite indices in interval 12. These indices reject the null hypothesis at various significance levels. The only interval where both the Z(q) and the Z*(q) statistics reject the null hypothesis is interval two, for all three indices of both markets.

Table 4.16: The results of the variance ratio tests for returns on indices for both Shanghai and Shenzhen markets throughout the period 2013-2015.

			Test intervals (q)				
Time Series	N		2	4	8	12	16
			E: 01/2013-12/2015				
Shanghai							
A Index	767	VR(q)	1.1286	1.0959	1.1717	1.2427	1.2526
		Z(q)	***3.5623	1.4200	1.6072	*1.7925	1.5894
		Z*(q)	**1.9940	0.7971	0.9287	1.0693	0.9715
B Index	767	VR(q)	1.2066	1.1745	1.2109	1.3393	1.3924
		Z(q)	***5.7208	***2.5829	**1.9742	**2.5065	**2.4691
		Z*(q)	**2.3437	1.0995	0.8786	1.1487	1.1621
Composite	767	VR(q)	1.1288	1.0959	1.1722	1.2436	1.2538
		Z(q)	***3.5662	1.4201	1.6120	*1.7997	1.5967
		Z*(q)	**1.9938	0.7964	0.9306	1.0724	0.9750
Shenzhen							
A Index	767	VR(q)	1.1503	1.2007	1.3225	1.4605	1.5003
		Z(q)	***4.1634	***2.9715	***3.0198	***3.4018	***3.1481
		Z*(q)	**2.4133	*1.7679	*1.8580	**2.1466	**2.0262
B Index	767	VR(q)	1.1676	1.1407	1.1657	1.2790	1.3406
		Z(q)	***4.6404	**2.0830	1.5517	**2.0609	**2.1430
		Z*(q)	**2.2994	**1.0850	0.8649	1.1999	1.2900
Composite	767	VR(q)	1.1505	1.2007	1.3229	1.4615	1.5017
		Z(q)	***4.1685	***2.9717	***3.0232	***3.4094	***3.1563
		Z*(q)	**2.4124	*1.7651	*1.8570	**2.1477	**2.0281

Note: VR(q) denote estimates of variance ratios. Z(q) and Z*(q) represent the asymptotic standard test statistics under homoscedasticity and heteroscedasticity, and q is the interval of the observations. The asterisks ***, ** and * represent 1%, 5% and 10% significance level, respectively.

The generated results from the variance ratio tests conclude that the daily A-share and Composite indices for the Shanghai market show signs of increasing efficiency between period B and D, which is consistent with the findings of Charles and Darné (2009). However, these indices have in recent years become less efficient according to the test statistics. A similar assumption could be made for the Shenzhen market, where the return series for A-share and Composite indices exhibit similar signs of randomness in period B. The efficiency of these indices tend to diminish as time progresses. Thus, the results of the variance ratio test suggest that the return on the indices for both markets have become increasingly inefficient over time and subsequently more predictable.

4.5 Daily Calendar Effect

Regarding the results of the tests on the daily calendar effect presented in Table 4.17 and 4.18, the Chinese stock market exhibits clear signs of inefficiency. All of the indices for both the Shanghai and the Shenzhen market has, at least, one significant day of the week effect.

For the Shanghai A-share and Composite indices, the negative mean returns observed on Tuesday are according to the t-statistics significant at the 5% and 10% level. The only day of the week effect that is present in all three indices of the Shanghai market is Friday, which is significantly positive at the 1% level for A-share and Composite indices, and at the 5% level for the B-share index. The findings are partially consistent with previous studies of Gao and Kling (2005), who observed that Mondays and Fridays, respectively, exhibit significantly negative and positive returns. Moreover, the results suggest that Wednesdays exhibit positive mean returns for both A-share and Composite indices of the Shanghai market, significant at 5% and 10% respectively.

Table 4.17: Results for daily calendar effects on index returns of Shanghai for the full sample period 1992-2015

Time Series	**Monday** b_1	**Tuesday** b_2	**Wednesday** b_3	**Thursday** b_4	**Friday** b_5	**F-value**
			Shanghai			
A Index	0,0002	-0,0014	0,0014	-0,0001	0,0018	**2,9288
t-value	0,2352	**-1,9928	**1,9813	-0,0965	***2,5850	(0,0121)
	(0,8141)	(0,0463)	(0,0476)	(0,9232)	(0,0098)	
B Index	-0,0002	-0,0010	0,0010	-0,0002	0,0013	*1,9900
t-value	-0,3142	-1,5272	1,6145	-0,4101	**2,1782	(0,0768)
	(0,7534)	(0,12678)	(0,1065)	(0,6818)	(0,0294)	
Composite	0,0002	-0,0013	0,0013	-0,0001	0,0017	**2,8614
t-value	0,2857	*-1,9446	*1,9478	-0,1466	**2,5746	(0,0138)
	(0,7751)	(0,0519)	(0,0515)	(0,8835)	(0,0101)	

Note: The coefficients b_i are represented in the first row for each day of the week followed by the t-statistic values in the second row. The statistics of the F-test for the day of the week effect are stated in the rightmost column. The numbers in parenthesis denote p-values for each corresponding statistic, while ***, ** and * represent 1%, 5% and 10% significance level, respectively.

Tests performed on the Shenzhen market indicate that the A-share index has a significantly negative mean return on Wednesday. A similar outcome is observed for the

Composite index, where the day of the week effect is also found on Wednesday but with a positive mean return. Both scenarios are statistically significant at the 5% level according to the t-tests. Furthermore, for the Shenzhen B-share index, the results signify a negative mean return on Tuesday and positive mean return on Friday, both of which are statistically significant at 5%.

Table 4.18: Results for daily calendar effects on index returns of Shenzhen for the full sample period 1992-2015

Time Series	**Monday** b_1	**Tuesday** b_2	**Wednesday** b_3	**Thursday** b_4	**Friday** b_5	**F-value**
			Shenzhen			
A Index	0,0006	-0,0006	0,0016	-0,0009	0,0010	**2,5549
t-value	1,0276	-0,9048	**2,5276	-1,4188	1,5805	(0,0257)
	(0,3042)	(0,3656)	(0,0115)	(0,1560)	(0,1141)	
B Index	0,0008	-0,0012	0,0009	0,0000	0,0014	**2,9606
t-value	1,3829	**-2,1801	1,4691	0,0449	**2,4449	(0,0113)
	(0,1668)	(0,0293)	(0,1419)	(0,9642)	(0,0145)	
Composite	0,0007	-0,0005	0,0014	-0,0009	0,0010	**2,4599
t-value	1,1304	-0,8464	**2,3720	-1,4088	1,6415	(0,0310)
	(0,2584)	(0,3974)	(0,0177)	(0,1589)	(0,1008)	

Note: The coefficients b_i are represented in the first row for each day of the week followed by the t-statistic values in the second row. The statistics of the F-test for the day of the week effect are stated in the rightmost column. The numbers in parenthesis denote p-values for each corresponding statistic, while ***, ** and * represent 1%, 5% and 10% significance level, respectively.

The F-statistics for all the indices on both the Shanghai and the Shenzhen market reject the null hypothesis of constant mean returns between the days of the week at 5% and 10% significance level. Hence, the different indices on the Chinese market exhibit indications of a day of the week effects, which implies that the market returns might not be following a random walk pattern.

5 | Conclusions

This paper explores the concept of weak-form efficiency through analysis of the two most influential stock markets in China using daily data of three indices for the Shanghai and Shenzhen market between 1992 and 2015. Due to the ever-changing economic climate in the country, the data set was split into four different sub-periods and examined individually, allowing assessment of whether the Chinese stock market efficiency is increasing over time. Furthermore, the daily calendar effect is studied for both the Shanghai and Shenzhen market to determine whether the Chinese stock market returns contradict the random walk hypothesis. The statistical techniques utilized in this paper are autocorrelation test, runs test as well as variance ratio test.

The overall conclusion based on the empirical findings from each test indicate that returns in the Shanghai and Shenzhen market do not follow a random walk pattern and consequently contradict the statements in the weak-form efficient market hypothesis. The generated results from the three statistical tests signify clear signs of predictability in returns in both Chinese markets.

The observations for all three tests unanimously reject the null hypothesis of a random walk in the full sample period. However, there are some inconsistencies to this remark within the examined sub-periods in both markets. The results from the runs tests reject the null hypothesis of a random walk in A-share and Composite indices in both markets between 1992 and 1995. The same results are observed in a later period for the Shanghai A-share and Composite indices between 2007 and 2012. Moreover, the results from the serial correlation test and variance ratio test both indicate that the A-share and Composite indices of the Shanghai market show signs of decreasing weak-form efficiency between 1996 and 2015. The Shenzhen market exhibit similar characteristics for the same indices at an earlier point starting 1992. Thus, according to the generated results the Chinese stock market have in recent years become less efficient. Furthermore, B-share indices of both markets consistently exhibit a greater degree of predictability compared to A-share indices, which according to previously conducted studies might be the result of thin trading.

The results of the tests for daily calendar effects suggest that all of the indices on the Shanghai and Shenzhen market support the presence of such an effect. Our results indicate that Tuesday for the Shanghai A-share and Composite indices, as well as the Shenzhen B- share index, are negatively significant. Also, returns on Wednesday are positively significant for Shanghai A-share and Composite indices, and the Shenzhen Composite index. The Shenzhen A-share index, on the other hand, is negatively significant for the same day. However, the most striking example is Friday, which exhibits a positive day of the week effect on all indices on the Shanghai market as well as the Shenzhen B-share index, which is consistent with previously conducted studies. Hence, all of the indices suggest that returns might not be following a random walk pattern.

The empirical findings in this paper are in line with previously conducted studies, suggesting that the Chinese stock markets not be weak-form efficient. The segmentation of two shares in the Chinese market along with the ever-changing political climate in the country might provide some explanation to the observed market inefficiency. Furthermore, most trades on the Chinese stock exchange are credited to retail investors rather than institutional investors, which could provide some valuable insight in understanding the extreme nature of the Chinese market. In comparison to well-developed markets in the U.S and Europe, the Chinese stock market has only been active for 20 years. Taking into consideration all the changes China has undergone these past years, it is not unreasonable to expect a lower degree of efficiency compared to its well-developed counterparts in the west.

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A | Figures

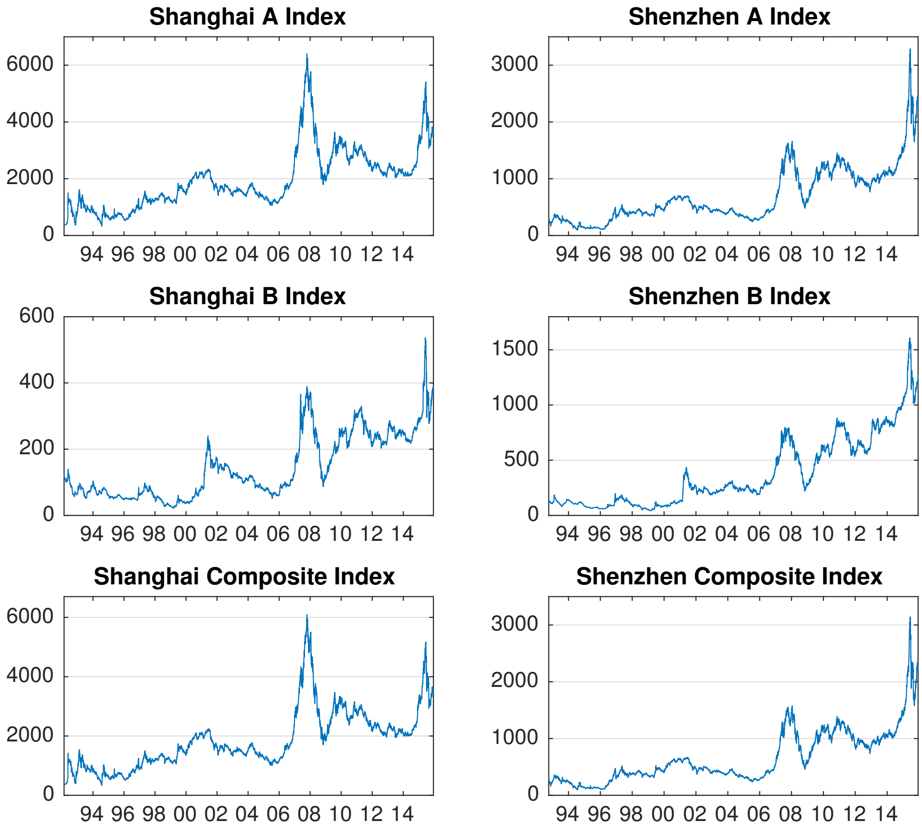

Figure A.1: Illustration of the time series plots of the Shanghai and Shenzhen indices. The daily closing price index is utilized for the full sample period ranging from February 1992 to December 2015. The A-share and Composite indices of the Shanghai and Shenzshen markets are denominated in Yuan (CNY), whereas the Shanghai B-share index is denominated in US dollar and the Shenzhen B-share index in Hong Kong dollar.

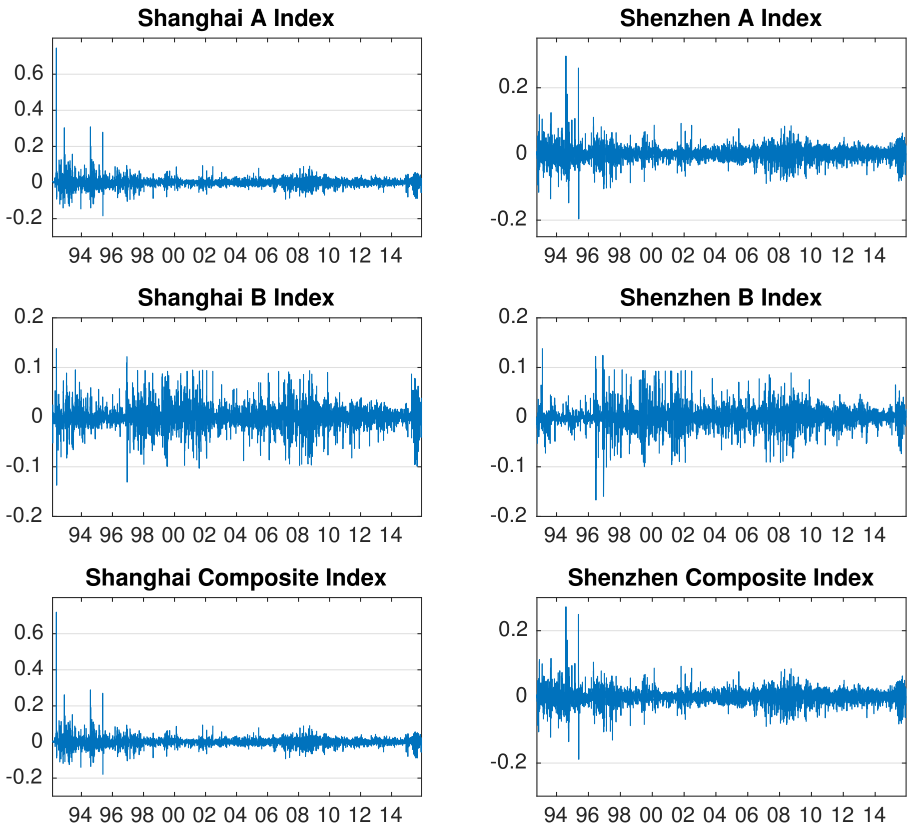

Figure A.2: Illustration of the log-returns for the Shanghai and Shenzhen markets between February 1992 and December 2015. The log-returns present the standardized differences between the consecutive time points.