LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
Department of Business Administration
Section of Accounting and Finance
Finance

TESTING WEAK-FORM EFFICIENCY OF THE CHINESE STOCK MARKET

The Department Council of the Department of Business Administration in Lappeenranta University of Technology has approved the subject of the thesis on February 14th, 2006.

Examiner and supervisor: Professor Mika Vaihekoski
Examiner: Professor Minna Martikainen

Kotka, September 18th, 2006

Hin Yu Chung
Ukonkatu 2
48600 Karhula
Tel. +358 50 529 9738

ABSTRACT

Author:	Hin Yu Chung
Title:	Testing Weak-Form Efficiency of the Chinese Stock Market
Department:	Department of Business Administration
Year:	2006

Master's Thesis. Lappeenranta University of Technology.
115 pages, 4 figures, 11 tables, 5 appendices

Examiners:	Professor Mika Vaihekoski Professor Minna Martikainen

Keywords:	Market efficiency, efficient market hypothesis, weak-form market efficiency, random walk, Chinese stock market, emerging stock markets, day-of-the-week effect

This study examines the random walk hypothesis to determine the validity of weak-form efficiency for two major stock markets in China. This study also provides evidence on the existence of the day-of-the-week effect on Chinese stock market.

Daily returns from February 21, 1992 to December 30, 2006 for the Shanghai A-share, Shanghai B-share, Shanghai Composite and Shenzhen Composite, and from October 5, 1992 to December 30, 2005 for Shenzhen A-share and Shenzhen B-share are used in this study. The random walk hypothesis is examined using four statistical methods, namely a serial autocorrelation test, a non-parametric runs test, a variance ratio test, and an Augmented Dickey-Fuller unit root tests. The day-of-the-week effect is tested using the ordinary least squares (OLS) regression. The statistical tests are conducted for full sample period and three sub-periods.

The empirical results of this study support previous studies that Chinese stock markets are weak-form inefficient. With the exception of the results from unit root test, results from serial autocorrelation test, runs test and variance ratio test are similar and reject random walk hypothesis for both Chinese stock markets. The results show that the behavior of B-share displays considerably more violations of the random walk hypothesis than A-share in both Chinese stock markets. Except the B-share market, efficiency also seems to improve after market boom in 2001 for both Chinese stock markets. The result also provides evidence that a day-of-the-week effect is existed on the Shanghai stock exchange, but not on the Shenzhen stock exchange during the full sample period.

TIIVISTELMÄ

Tekijä:	Hin Yu Chung
Tutkielman nimi:	Markkinatehokkuuden heikkojen ehtojen toteutuminen Kiinan osakemarkkinoilla
Osasto:	Kauppatieteiden osasto
Vuosi:	2006

Pro gradu -tutkielma. Lappeenrannan teknillinen yliopisto.
115 sivua, 4 kuvaa, 11 taulukkoa, 5 liitettä

Tarkastajat:	Professori Mika Vaihekoski Professori Minna Martikainen

Hakusanat:	Markkinatehokkuus, tehokkaiden markkinoiden hypoteesi, markkinatehokkuuden heikot ehdot, satunnaiskulku, Kiinan osakemarkkinat, kehittyvät markkinat, viikonpäiväanomalia

Tämän tutkielman tavoitteena on tarkastella Kiinan osakemarkkinoiden tehokkuutta ja random walk -hypoteesin voimassaoloa. Tavoitteena on myös selvittää esiintyykö viikonpäiväanomalia Kiinan osakemarkkinoilla.

Tutkimusaineistona käytetään Shanghain osakepörssin A-sarjan, B-sarjan ja yhdistelmä-sarjan ja Shenzhenin yhdistelmä-sarjan indeksien päivittäisiä logaritmisoituja tuottoja ajalta 21.2.1992–30.12.2005 sekä Shenzhenin osakepörssin A-sarjan ja B-sarjan indeksien päivittäisiä logaritmisoituja tuottoja ajalta 5.10.1992–30.12.2005. Tutkimusmenetelminä käytetään neljä tilastollista menetelmää, mukaan lukien autokorrelaatiotestiä, epäparametrista runs-testiä, varianssisuhdetestiä sekä Augmented Dickey-Fullerin yksikköjuuritestiä**.** Viikonpäiväanomalian esiintymistä tutkitaan käyttämällä pienimmän neliösumman menetelmää (OLS). Testejä tehdään sekä koko aineistolla että kolmella erillisellä ajanjaksolla.

Tämän tutkielman empiiriset tulokset tukevat aikaisempia tutkimuksia Kiinan osakemarkkinoiden tehottomuudesta. Lukuun ottamatta yksikköjuuritestien saatuja tuloksia, autokorrelaatio-, runs- ja varianssisuhdetestien perusteella random walk -hypoteesi hylättiin molempien Kiinan osakemarkkinoiden kohdalla. Tutkimustulokset osoittavat, että molemmilla osakepörssillä B-sarjan indeksien käyttäytyminen on ollut huomattavasti enemmän random walk -hypoteesin vastainen kuin A-sarjan indeksit. Paitsi B-sarjan markkinat, molempien Kiinan osakemarkkinoiden tehokkuus näytti myös paranevan vuoden 2001 markkinabuumin jälkeen. Tutkimustulokset osoittavat myös viikonpäiväanomalian esiintyvän Shanghain osakepörssillä, muttei kuitenkaan Shenzhenin osakepörssillä koko tarkasteluajanjaksolla.

ACKNOWLEDGEMENTS

The feeling of satisfaction that I have finally accomplished my work is impossible to describe in words. Working with this thesis has been very challenging but also a very rewarding experience. This master thesis would not have been possible to complete without motivation, support and assistance of a number of people. I would like to take this opportunity to express my sincere gratitude to all those who made this effort possible.

I would like to thank Professor Mika Vaihekoski for his supervision, guidance and valuable advice through the process of this thesis and Professor Minna Martikainen and Professor Eero Pätäri for their comments.

I am grateful to Päivi, Charis and my sister Fiona for reading my work and giving feedback and encouragement and to my friends for their ideas and support.

I want to thank my parents, sisters and brothers for their love and support. Fulfilling this goal would not have been possible without them. Finally, I want also to thank Kei for his support and understanding during the process of this work and for so many other things.

Kotka, September 18th, 2006

Hin Yu Chung

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 Background of the Study

Since the research contribution of Fama (1965, 1970), there is a common observation among analysts, researchers and practitioners in financial economics that stock prices or returns exhibit a random walk behavior. This randomness, which forms the theoretical basis of the weak-form efficient market hypothesis, states that successive stock prices or returns are independently and identically distributed; that past stock prices have no predictive content to forecast future stock prices. (Fama 1995) Statistically, the random walk hypothesis is an independence test, which hypothesizes that stock prices are characterized by a white-noise process, a stable first-order autoregressive pattern, a unit root process, or a low correlation dimension. Because financial time series such as stock prices exhibit nonlinearity and time-varying volatility, studies that are more recent tend to employ variance ratio and BDS tests to examine the existence of long-term dependence in stock prices or returns.

Over recent decades, there has been a large body of empirical research concerning the validity of the random walk hypothesis or weak-form efficient market hypothesis with respect to stock markets in both developed and developing countries. Empirical research on testing the random walk hypothesis has produced mixed results. For example, most early research is supportive of the weak and semi-strong forms of the efficient market hypothesis in developed capital markets (see, e.g., Osborne 1962; Granger and Morgenstern 1963; Fama 1965; Ball and Brown 1968). Recent research, however, has reported that stock market returns are predictable (Poterba and Summers 1986; Fama and French 1988; Lo and MacKinlay 1988). The empirical evidence is also mixed for the developing countries. These studies on emerging stock markets can be divided into two groups depending on findings. Researches who finds the evidence to support the weak-form efficiency (e.g., Urrutia 1995; Ojah and Karemera 1999; Abrosimova et al. 2005; Moustafa 2004), and others shows the evidence of predictability or rejection of the random walk hypothesis in stock returns (e.g., Huang 1995; Poshakwale 1996; Mobarek and Keasey 2002; Khaled and Islam 2005).

Considering the theoretical and practical significance, the testable implications and conflicting empirical evidence of the random walk hypothesis motivates us to have a fresh look at this issue of weak-form efficiency in the context of an emerging market, namely Chinese stock market. This study is potentially interesting case study for a developing capital market, which shares most of the characteristics of a typical emerging market.

China launched two stock exchanges as part of concerted efforts towards a market-oriented reform – the Shanghai Stock Exchange in 1990 and the Shenzhen Stock Exchange in 1991. Since the establishment of organized stock exchanges in Shanghai and Shenzhen, these two Chinese stock markets have expanded rapidly and have operated in a continually changing regulatory environment. Chinese stock market indeed has been one of the fastest growing emerging capital markets, and that market is now even the second largest in Asia, behind only Japan. Stock markets in China also differ along many dimensions from most emerging markets, such as segmentation of two share and political environment, which altogether affect its market operation. Observing that China has one of the fastest growing economies in the world and, further, that the government is committed to continuous privatization and liberalization, the rapid development of Chinese stock markets is likely to continue into the near future.

There have been a few previous studies concentrated on testing for efficiency of the Chinese stock markets (e.g., Laurence et al. 1997; Mookerjee and Yu

1999; Lima and Tabak 2004). However, these previous studies have focused on the initial years immediately after two Chinese stock markets were established in the early 1990s, often analyzed relatively few indexes or used a short period of data. Therefore, this study attempts to examine the validity of the random walk hypothesis or weak-form efficient market hypothesis of Chinese stock market using various indexes of both Chinese stock markets and the longest possible sample data.

1.2 Objectives and Methodology

The main objective of this study is to examine whether the two major Chinese stock markets in Shanghai and in Shenzhen are weak-form efficient over the period 1992-2005. Purpose of this study is also to find out whether Chinese stock returns violate the random walk hypothesis. We employ daily data for six share price indexes using the longest possible sample sizes and various types of the statistical tests to examine market efficiency. The specific objectives of the study are:

- to determine whether the Chinese stock market follows a random walk model or is weak-form efficient
- to determine whether the Chinese stock market exhibits a trend towards increased efficiency over time
- to determine whether there is difference in the returns between the days of the week

This study applies a classical framework of testing market efficiency. To determine whether or not the time series predictability in Chinese stock returns violate the random walk model, which maintains that past stock return changes cannot be used to predict future stock returns, statistical tests including autocorrelation, runs test, variance ratio and unit root tests for null hypothesis of a random walk are employed. To examine further, our second objective is to find out whether Chinese stock market efficiency has improved over time and in an attempt to present a general picture of resent development of the Chinese stock market and its performance. Since the most serious violations of the random walk hypothesis on developed markets and emerging markets as well have been associated with widely documented seasonal anomalies, our final objective is to investigate whether returns of both Chinese stock markets are different between the days of the week.

1.3 Limitations of the Study

This study focus on market efficiency, however the existing the market efficiency literature has become extremely extensive, that even a careful survey of it is undoubtedly beyond the scope of this thesis. Consequently, we only provide a short discussion of central findings in the market efficiency literature regarding to random walk hypothesis or weak-form efficiency in order to provide a general picture of this study.

The most important limitation of this study is that the empirical part of this study restrict exclusively for weak-form efficient market hypothesis or return predictability using time series analysis of stock return behavior. Accordingly, the statistical tests is only employed for testing market efficiency, thereby technical trading rules or adjusting transactions cost such as bid-ask spread and time lag of settlement procedures is excluded in this study.

Finally, it is also important to take into consideration that a number of previous studies have documented that Chinese stock market inefficiency may stem from thin trading, which is also a widely documented typical characteristic in most emerging stock markets, can produce serious bias in empirical work. This study, however, only uses daily data, even thought this might lead possible bias in empirical work. We use a longer time-period, which may reduces this problem and increase the power of random walk test (Lo and MacKinlay 1988).

1.4 Outline of the Study

The remainder of this study is organized as follows. Section 2 provides background on the institutional nature and development of the stock markets in China, as well as discusses some special features related to efficiency of Chinese stock market. In the section 3, the efficient market hypothesis is explained in a theoretical and an empirical point of view. It also reviews the previous empirical evidences on weak-form efficiency in developed, emerging and Chinese stock markets as well. Section 4 describes the data, hypotheses and methodology of the empirical research. Section 5 presents the empirical results and section 6 summarizes the results of this study and draws conclusion as well as provides suggestions for future research.

2. CHINESE STOCK MARKET

2.1 Background

Since the beginning of the economic reforms in 1978, China's real gross domestic product (GDP) has been growing averaged over 9 percent a year. The economic reforms in the late seventies and eighties have strongly remodeled its agricultural, industrial and financial sectors. China's economy has historically been agrarian, but it is now heavily weighted towards industry, manufacturing and construction, which together comprise 53% of its GDP, followed by services 32%, and agriculture 15%.[1] (The World Bank 2005) As part of remarkable economic reforms, the financial sector of China also went through a number of institutional changes. Financial reforms introduced in 1981, included reform of capital market, banking and enterprise financing. Capital market reform aimed at reducing mandatory state allocation of capital and at creating alternative channels for raising capital such as bonds and stocks. Enterprise reform targeted at enhancing enterprise autonomy in raising capital and in management by restructuring state-owned or collective enterprises into shareholding companies. (Tan 2004)

One of the most important elements of China's financial system reformation is the development of the Chinese stock market. Chinese stock market as part of financial reform evolved from the planned economy. The principal idea was to create the market a source for supplementing China's inadequate capital for its goal of modernization. Capital markets is considered an effective way to get access to the huge amount of public savings, which would reduce inflation pressure, thereby ease price reform, and to provide an additional path for foreign investment. It is also a mean to ensure the smooth transition

[1] Structure of China's economy in 2004 is based on the data published by the World Bank Group (2005).

to a market system for state-owned enterprises (SOE). Therefore, the stock market is regarded as a vehicle for providing long-term capital for the expansions of the enterprises and for financing infrastructure projects. (Mookerjee and Yu 1999; Tan 2004)

2.2 Development of the Chinese Stock Market

Since its establishment, the Chinese stock market has experienced tremendous development over the past decade. This development has proceeded through several major stages. The first stage took place from 1984 to 1989. Informal markets in company stocks were first established in the early 1980s when local governments started to allow enterprises to issue bonds and stocks. With experiments in stockholding, many collective firms issued debentures and internal employee shares. In 1984 a system joint stock or shareholding companies was widely introduced after the initial experiment of shareholding reform. (Tan 2004)

In 1985, Shanghai Yanzhong Industrial made the first public offerings of standardized corporate equity in reform China. Small OTC markets were established in Shanghai and Shenyang in late 1986. The capital markets evolved more rapidly than the government anticipated as firms sought new ways to raise capital and residents to invest. Government regulation of the market activities therefore came only after the fact. Soon after the Tiananmen Square protests in May and June 1989, Deng Xiaoping gave his approval to the establishment of a stock exchange in Shanghai. Shenzhen received Beijing’s official approval later in mid-1991. (Green 2003, 9)

The second stage of the Chinese stock market development was from 1990 to 1992. Two official securities exchanges were established, the Shanghai Securities Exchange (SHSE) in 1990 and the Shenzhen Securities Exchange

(SZSE) in 1991. Regular trading sessions started at the SHSE on December 20, 1990 and at the SZSE on April 4, 1991. The People's Bank of China (PBOC) and local governments first regulated two stock exchanges, due to illegal trading problems in Shanghai and Shenzhen between 1990 and 1991; in 1992, the regulatory competence was transferred to the State Council Securities Commission (SCSC) and the China Securities Regulatory Committee (CSRC). (Tan 2004) In the same time, companies were permitted to issue so-called B-shares to foreign investors in addition to the existing A-shares issued to domestic investor.[2] This stage, as its early time, was contaminated by stock market fewer, which broke out in the south of China in 1992, ignited by Deng Xiaoping's southern tour declaring that China would replace the planned economy with the market economy. (Green 2003, 13)

The third stage was the period from 1994 to 1995. The fever between 1992 and 1993 was, however, short-lived. The stock markets boomed and suffered during Beijing's monetary -retrenchment campaigns to restrain inflation during the period 1993 to 1995. Excessive issuance of securities, often without PBOC approval had contributed to the inflationary expansion in money supply and investments between the periods 1992 to 1993. In 1994 and 1995, the central government forcefully tightened the share issuance quota and trading volumes slumped. In order to retain control, the state created three different share categories, which are explained in Table 1. Any state-owned enterprises (SOE) converting into a shareholding company is ordered to divide its capital into three parts: individual person, legal person and state shares, each roughly equal. This requirement is still in place. (Green 2003, 13-15; Groenewold et al. 2003)

---

[2] This practice is institutionalized because China, like many developing economies in the world, has strict capital control regulations. In order to attract foreign capital and to limit capital outflow, Chinese companies are permitted to issue B-shares denominated in Yuan but transacted in foreign currencies (U.S dollars in Shanghai and Hong Kong dollars in Shenzhen) to foreign investors. B-shares can only be issued after the A-shares are made available to Chinese investors. (Green 2003, 47)

Table 1. Share Categories of Chinese Stock Market

Type	Description
A-shares (individual)	Shares of Chinese companies traded in Shanghai and Shenzhen, denominated in renminbi and owned by individuals and legal persons.
B-shares (individual)	Shares of Chinese companies traded in Shanghai and Shenzhen, denominated in US$ in Shanghai and HK$ in Shenzhen and the market is now open to domestic individuals.
Legal person (LP) shares	About a third of every listed firm's equity is transferred to domestic institutions (securities companies and SOEs with at least one-state owner) and cannot be traded.
State shares	Another a third of equity is transferred to state (central and local government bureau); SOEs are wholly owned by the state as well and cannot be traded.[3]
H-shares	Shares of Chinese registered companies listed in Hong Kong.[4]
Red-ships	Shares of Chinese companies registered overseas and listed abroad (principally in Hong Kong), having substantial Mainland interests and controlled by affiliates or bureaus of the government.

Source: Green (2003, 16)

Legal-person shares commenced to on the Securities Trading Automated Quotation System STAQS in 1992 and the National Electronic Trading System NETS in 1993 as part of an experiment to liquidize the non-negotiable shares. However, due to excessive speculation and the lack of proper regulation, in June 1993, the listing of legal-person shares on any markets was banned by the China Securities Regulatory Committee (CSRC), and further to regulate the legal-person share market, both STAQS and NETS were finally closed by the government in 2000. (Green 2003, 17-18)

In the fourth stage, the central government's attitude to stock markets changed radically during 1996-1997. After a series of failed experiments with

[3] State shares represent the part of the firm owned by the state. These shares are hold by the State Asset Management Bureau (SAMB) and are not tradable on the stock exchanges. Legal person shares represent the part of the firm owned by other state entities. Like state shares, legal person shares cannot trade on the stock exchanges. Public shares are the ordinary A-shares B-shares that are freely tradable on the stock exchanges. (Green 2003, 16)

[4] Mainland Chinese firms listed in New York and London are called N-shares and L-shares; thought the term H-shares is also used. (Green 2003, 16)

limited-responsibility contracts, profits retention, and other mechanisms by which the state sought to create better incentives for SOE managers, the government turned to corporatisation as the solution to the SOE problem. In late 1996, the central government determined that transformation of SOEs through public issuance of equity shares as well as the stock markets itself should be promoted as part of this industrial restructuring programme. Efforts to implement shareholding reforms were also intensified. The markets started to grow rapidly since 1996. In April 1996, the CSRC gave the first public signals of the new positive attitude to the stock markets, ending the period of retrenchment that had preceded a number of scandals earlier. (Green 2003, 21-23)

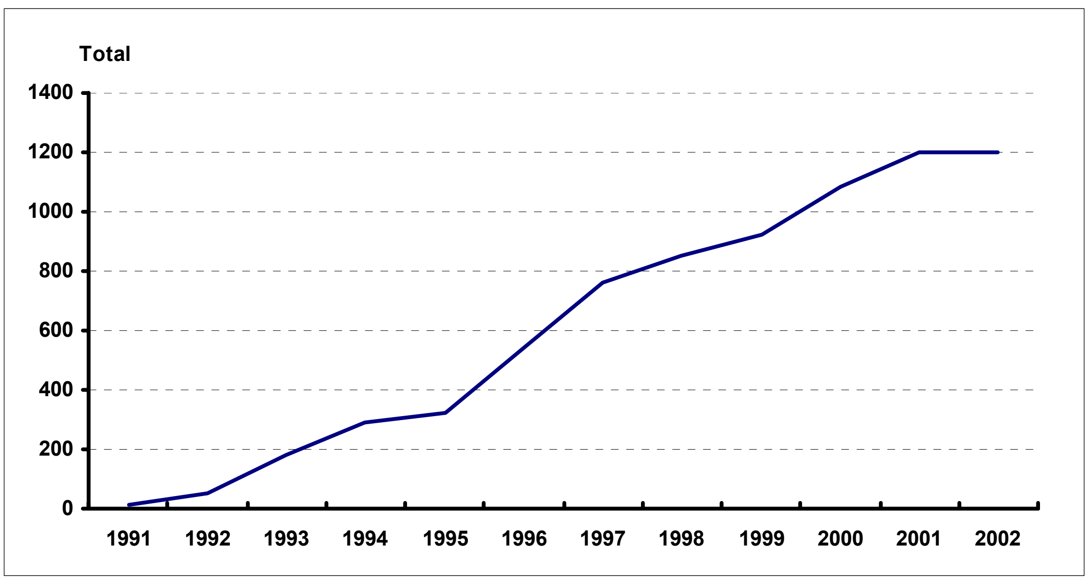
The third and fourth stages were also featured with the construction of a formal legal and regulatory framework for the securities sectors. China did not have a special central agency to regulate securities markets until the early 1990s. As mentioned earlier, at very beginning the two exchanges was regulated by the People's Bank of China (PBOC) and local governments, but confusions and conflicts resulted the creation of the centralized market regulatory body. The formation of the State Council Securities Commission (SCSC) and China Securities Regulatory Committee (CSRC) in 1992 marked the first effort to establish unified regulatory control over the market. SCRC was charge with the primary authority for market regulation, while the CSRC was responsible for a supervisory and executive role over the Chinese stock markets. Law which contain provisions on issuance, transacting, and listing of public offerings was introduced in 1994. (Tan 2004) Significant improvements to regulation have taken place since the 1997 Asian crisis. Essential changes in Chinese stock markets occurred in April 1998, when SCRC and CSRC merged to form one ministry rank directly under the State Council as part of the government's plan for improving regulatory effectiveness. With the merger, the CSRC became the sole national regulatory authority over the securities industry. In August 1998, the Shanghai and the Shenzhen stock exchanges were placed under the supervision of the CSRC. (Shirai 2004) Since 1998 with the CSRC in charge, the Chinese stock market became more stable and its growth has been huge (Green 2003, 21-23).

The final major stage of Chinese stock market development was from 1999 to 2002, when China Securities Act tool effect in 1999 and that China joined to WTO in 2001. The Securities Law became was enforceable effective 1st July 1999, which aim to prohibit insider trading, standardize the issuing and trading of securities, improve disclosure, and protect investors. The bubble that inflated during 1999-2000 burst in the second half of 2001. Behind this was that the CSRC started its most serious crackdown on yet illegal activities. Since the beginning of 2000, government started to roll out a series of new, market-oriented policies aiming to improve efficiency of market. This process was called “re-regulation”. (Green 2003, 23-25) Controls were tightened against illegal stock price manipulation and false information disclosure has been tightened. In addition, an attempt to improve the quality of listed companies, the accounting rules were tightened for firms seeking IPOs. The CSRC also introduced the Code of the Corporate Governance for listed companies, which stimulates the rights and responsibilities of shareholders, directors, and management. (Shirai 2004)

In early 2001, ease on restrictions on local investors buying B-shares. The ease allows Individual Chinese investors with legal foreign exchange accounts are allowed to buy and trade B-shares. (Seddighi and Nian 2004) Despite the release from restriction and many years of development, the B shares market remains small in terms of both the number of listed companies and market capitalization (Green 2003, 55). Since China joined the WTO in December 2001, foreigners have gained larger space in the capital markets as well as in securities service business. Recent movements include the allowance of foreign institutional investors to buy and sell A-shares[5], more flexibility for takeovers of Chinese companies by foreigners, as well as greater market access for foreign securities business. (Green 2003, 199-200)

Even though the Chinese stock market has a very short history, but its growth has been remarkable. Figure 1 performs a growth of number of listed companies in Chinese stock markets and Figure 2 presents amount of the total market capitalization of the Chinese stock market during 1991-2002. The number of listed companies listing has accelerated since 1996. Over the first six years (from 1991 to 1995), Chinese stock market listed only 323 companies, but the total of listed companies nearly tripled 923 over the following four years (1996-1999). By the end of 2002, listed companies reach to 1200 companies.

Figure 1. Number of Listed Companies in the Chinese Stock Market during 1991-2002

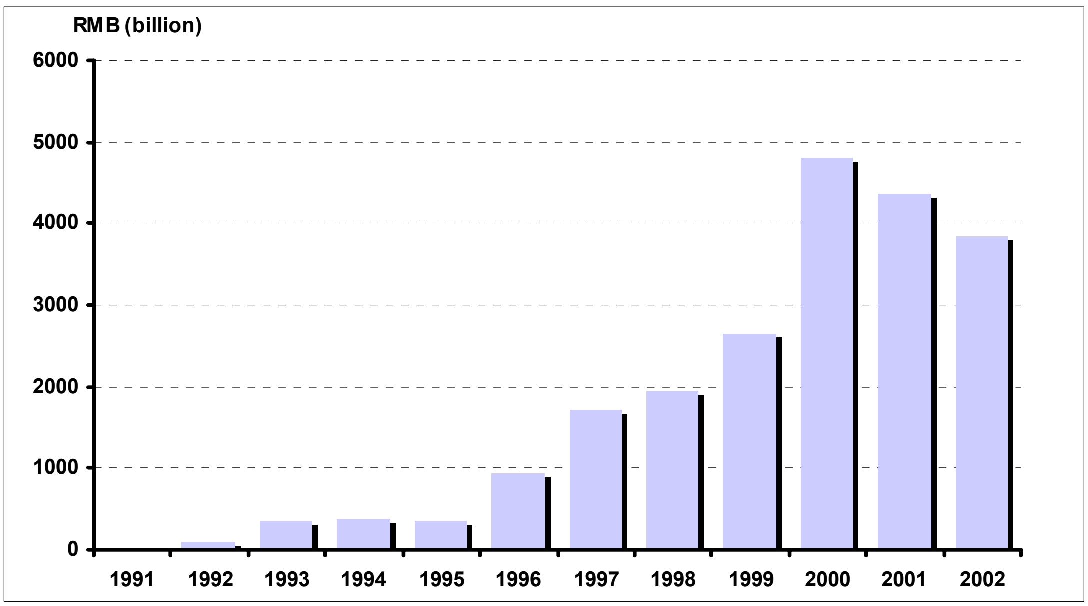


Source: Shanghai Stock Exchange and Shenzhen Stock Exchange

[5] In December 2002, the Chinese government launched the qualified foreign institutional investors (QFII) policy that permits large foreign institutional investors to invest in local-currency denominated securities including A-shares (Shirai 2004).

The amount of market capitalization has similarly increased steadily since 1996, from Rmb 943.9 billion that year to a peak of Rmb 4809.1 billion in 2000. A massive price fall occurred in 2001-2002. Chinese stock markets were down by half during the past four years since 2001 (People's Daily Online 2005).

Figure 2. Market Capitalization of the Chinese Stock Market during 1991-2002



Source: China Securities Regulatory Committee (CSRC) and Green (2003, 28)

2.3 Stock Exchanges

China has two official securities exchanges, and two nationwide trading systems including the Securities Trading Automated Quotation System (STAQS) and the National Electronic Trading System (NETS), and a number of regional trading centers. (Green 2003, 15-17) Shanghai Securities Exchange (SHSE) and the Shenzhen Securities Exchange (SZSE) are both non-profit membership institutions providing clearing, settlement, custody and registration services to their members. They are under the supervision of the Chinese Securities Regulatory Committee (CSRC), which is responsible for the overall day-to-day supervision and administration of the two securities exchanges. The companies from all over China are permitted to list on either of the exchanges, but dual listing is not allowed and each exchange can only trade the shares listed on its own index. A and B-shares of a larger number of SOEs, high quality private enterprises and few foreign invested companies are listed on both exchanges. (Shanghai and Shenzhen Stock Exchanges)

2.3.1 Shanghai Stock Exchange

The Shanghai Stock Exchange (SHSE) was founded on November 26, 1990 and officially in operation on December 19, 1990. SHSE uses a computerized trading system that is based on the principle of price priority and time priority. The trading hours of the SSE are from every Monday to Friday. The trading session of the SHSE is from 9:15am to 9:25am for centralized group bidding; from 9:30am to 11:30am and from 13:00pm to 15:00pm for consecutive bidding. (Shanghai Stock Exchange) Currently, the A-share market adopts T+1 settlement[6] and the B-share market uses T+3. This settlement is valid in both the Shanghai and the Shenzhen stock exchanges. (Seddighi and Nian 2004)

Securities listed on SSE fall into three categories: stocks, bonds and investments funds. Stocks are further divided into A-shares and B shares, where A-shares are designed for domestic investors and B-shares are for all investors. (Shanghai Stock Exchange) The Shanghai Securities Exchange Index is a value-weighted average market-capitalization index. Its base date is December 9, 1990, and its base value is 100. The index comprises all listed shares. (Lee et al. 2001) The Shanghai Stock Exchange share price index series are divided into 4 categories in 13 different indices[7]. Among them, the SHSE Composite Index, SHSE 180 Index, SHSE A-Share Index

---

[6] Investor can buy on a day and sell next day.

[7] Detailed information about the SHSE share price index series is provided in the Appendix 1.

and SHSE B-Share Index are the most important ones. SHSE Composite is the earliest compiled, which comprise all A-share and B-share companies listed on the SHSE. Components of SHSE 180 Index are 180 stocks selected from the most representative stocks from A-share pool.[8] SHSE A-Share Index includes all A-share companies, while B-Share Index consists of all B-share companies listed on the exchange. (Shanghai Stock Exchange "Fact Book" 2004)

By the end of 2003, there were 780 companies and 913 securities including 770 A-shares and 54 B-shares listed on the SHSE. The total stock market capitalization amounted to $360 billion. The SHSE had 177 members, 135 of which were security dealers and 42 non-security dealers. The members had 2968 business departments with 4522 trading seats, 4222 for A-shares and 300 for B-shares. (Shanghai Stock Exchange "Fact Book" 2004)

2.3.2 Shenzhen Stock Exchange

The Shenzhen stock market was officially recognized on July 3, 1991. Shenzhen stock market consists of the exchange, the stock registration company, several hundred brokerage firms, and several million institutional and individual investors. Trading ranges are stocks including A-share and B-share, debts and mutual funds. Like the SHSE, the SZSE also uses a computerized trading system based on the principle of price priority and time priority. The market trades four hours a day and five days a week from 9:30am to 11:30am and from 13:00pm to 15:00pm. (Shenzhen Stock Exchange)

The Shenzhen Securities Exchange Index is also a value-weighted average market-capitalization index (Lee et al. 2001). The SZSE publishes 10 different

[8] For further information, see SHSE Fact Book 2004.

indices. On the SZSE, the main indices are the SZSE Composite Index, SZSE Component Index; SZSE A-Share Index; and SZSE B-share Index.[9] They are basically similar to the indices on the SHSE. The SZSE Composite Index includes all A-share and B-share companies listed on the SHSE, is also the earliest index on the SZSE. (Shenzhen Stock Exchange) By the end of 2003, there are 507 listed companies and 548 listed stocks on the SZSE. The total market capitalization was $152.8 billion, and there were 205 members, 3427 trading seats and 52 seats were for B-shares. (Shenzhen Stock Exchange "Fact Book" 2003)

The most distinct differences between two stock exchanges are the relative size and the characteristics of listed companies of two exchanges. While most companies listed on the SHSE are large and state-owned, those on the SZSE are small, joint ventures and export-oriented. The relative size of two exchanges has changed since their establishment. In 1992, the SZSE were still larger and more active than the SHSE, but due to government policy by the end of 1994, the situation started to change. (Cheng 2000) Today the market capitalization of the SHSE is nearly 3 times larger than the SZSE, and about 830 listed companies in the SHSE, while about 540 companies listed in the SZSE (Shanghai and Shenzhen Stock Exchanges). Nevertheless, both stock exchanges have growth tremendously since its establishment.[10]

2.4 Special Features of the Chinese Stock Market

Chinese stock market had several unique features that made its rapid development unique and interesting. Absent of the knowledge of the key characteristics of the market it is difficult to understand operation and

[9] Detailed information about the SZSE share price index series is provided in the Appendix 2.
[10] Appendix 3 summarizes some of performance indicators of the both exchanges from 1996 to 2005, which reflect the recent development of the both stock exchanges.

efficiency of the Chinese stock market. Dow Jones Indexes (2002) identified fourteen key features of Chinese stock market using Dow Jones Global Index and Dow Jones China Index as tools. Some of them, because of their relevance to explain efficiency of Chinese stock market, are discussed below.

Chinese stock market displays unique performance since the inceptions of the two exchanges in the early 1990s. According to the Dow Jones Index report, Chinese stock delivered impressive returns during the eight-year period from 1994 to 2001, as measured by the Dow Jones China Index consisting of 549 stocks as of January 31, 2002. Chinese stock market outpaced many of the world's leading indexes including Japan's Nikkei 225, Hong Kong's Hang Seng Index, the Dow Jones STOXX 600 covering Europe, as well as the Dow Jones World Emerging Markets Index covering eleven major emerging markets around the world. The performance, however, could be characterized by as abnormal because it is not based on the performance of the listed companies and the China's economy as well. The report yet suggests that the historical outperformance of Chinese stock market is concentrated on a particular year, on particular days and within a particular segment of the market. (Dow Jones Indexes 2002)

One even more special feature of the Chinese stock market is the variety of the types of stocks issued by the listed companies as mentioned earlier. Class A-shares are restricted to domestic investors. Class B-shares originally were only available to foreign investors have been open to local Chinese investors since 2001, but this performance has lagged far behind of the A-share market. A total market value of B-share market is only about 2.4% of the A-share market. According to the Jones Index report, market segregation and the foreign exchange control regime helped China to protect its economy and markets during the Asian financial crisis of 1997. However, in recent years the segregation is increasingly viewed as a barrier between Chinese capital markets and international investors. (Dow Jones Indexes 2002)

The depth and breadth government ownership of publicly traded companies is also another unique feature of Chinese stock market. According to a Dow Jones survey, the average government ownership in Chinese stock was 45 percent, as of January 31, 2002, with maximum of 89 percent. Such a high percentage of government ownership does not exist in any other stock market in the world. (Dow Jones Indexes 2002) The government not only owns a major proportion of firms' assets but also is directly involved in many aspects of corporate management, including personnel, financing, and production. Firms may also have investments from other state-owned enterprises (SOE), resulting in an interlocked ownership structure for many Chinese firms. (Green 2003, 123) Government ownership is seen as a serious obstacle to the healthy development of Chinese stock market (Yu et al. 2005).

Due to lack of regulatory experience, rule of law, and of fully developed market economy, Chinese stock market also possesses many of the features that are characteristics of emerging markets. First, China has many types of share classes that confuse investors. Besides A-shares and B-shares, there are also several additional classes available to global investors and denominated in free exchangeable currencies, such as H, N, L and S shares are listed in Hong Kong, New York, London and Singapore, respectively. Secondly, initial public offerings (IPO) are strictly regulated in China (Yu et al. 2005). China is identified by the Dow Jones report, as "China is the only country in which the government completely controls the size of the stock market, the pace of issue and the allocation of resources". Thirdly, the market is predominated by small-cap stocks rather than blue-chip companies, in both absolute size and in relation to the rest of the world, due to the fact that most of China's blue -chips are listed only on overseas exchanges and are not available to domestic investors. Fourthly, another unusual feature of Chinese stock market is dominance of retail investors. While in developed markets institutional investors tend to dominate markets, institutional investors are underdeveloped in Chinese stock market. Finally, contrary to the global trend of consolidating multi exchanges of a single jurisdiction into a single-exchange structure, China has two exchanges of similar size, performing virtually the same functions on every aspect. However, the stocks traded on the two exchanges perform quite differently. (Dow Jones Indexes 2002)

The characteristics of the market themselves, the multitude of government interventions, and the macroeconomic situation all greatly influence the Chinese stock market. (Yu et al. 2005) While as Eastern Europe's stock markets benefited from new politics and a general acceptance of privatization, and Asian's market grew up alongside the region's economic growth miracle, Chinese stock market was created in the midst of a large number of obstacles. It is alleged that stock market development in transitional countries is strongly correlated with low inflation, the existence of sizeable institutional investors and a legal framework that protects minority shareholders' rights. In the contrary, Chinese stock market coped with a Communist government, two very serious inflation in 1988-1989 and 1992-1993, few institutional investors and poor regulation combined with weak enforcement.[11] (Green 2003, 35-36)

Although the Chinese stock market has developed rapidly and has started its liberalization process recently, it still has a long way to go before they will compel international investors to commit significant amounts of capital. The investment opportunities in the market, especially for foreign investors, are still restrictive. Although most emerging markets have completely removed the ban on foreigners investing in their markets, China has not yet reached such a stage. The emergence of global companies like Samsung in South Korea, Nokia in Finland or Toyota in Japan would be an important factor in increasing the value of the Chinese stock market. At present China has no global company. (Norges Bank 2006)

---

[11] Appendix 4 provides some market statistics of several emerging markets and developed markets as comparison with Chinese stock market.

3. THEORETICAL FRAMEWORK

3.1 The Concept of Market Efficiency

Efficiency in the context of capital market has been defined in many ways, but the most common way has been defined it in terms of what sort of information is available to market participants, and how they handle that information. According to this view, an efficient capital market is one where prices of financial assets accurately reflect all information and quickly adjusts to new information. (Dimson and Mussavian 1998) This definition is referred to informational efficiency. Nevertheless, the markets are also economic institutions that require resources and economic agents. Efficient markets in this wider economic sense are involved in allocating resources to their most profitable use and in cost effective ways. This is called allocative efficiency. Capital market can also be defined as operational efficient, which also often appears in the finance literature. The concept of operational efficiency pertains to a market's ability to provide liquidity, rapid execution and low trading costs. (Sharpe et al. 1999, 92) This study is concerned with the term of informational efficiency.

Capital market efficiency is also used to refer to a perfect market. However, it is important stress that an efficient market is not synonymous with a perfect market. A perfect market has a more restrictive definition. In such a market, all market participants are assumed to be rational and have immediate and simultaneous access to all relevant information. The information is supposed to be without costs. Furthermore, a perfect market is assumed to be frictionless, where there is no transaction costs, with fully dividable assets and without restrictive legislation. It is also characterized by open competition in product markets as well as in capital markets. In reality, markets are neither perfectly efficient nor completely inefficient. All markets are efficient to a certain extent, some more than others. (Fama 1970; Sharpe et al. 1999, 92-93) For example, the securities markets in developing countries are considered to be less efficient because of their operating characteristics such as size, market regulation, trading costs and nature of the investors and different participants may have varying amounts and quality of information. The perfect markets are efficient markets, but efficient markets are not necessarily perfect markets. (Dickinson and Muragu 1994)

3.2 Efficient Market Hypothesis

3.2.1 Development of the Theory of Efficient Market

The efficient market hypothesis is a concept of informational efficiency, and refers to market's ability to process information into prices. The idea of the efficient market hypothesis (EMH) emerged as early as the beginning of the twentieth century in the theoretical contribution of Bachelier (1900) [12] and the empirical research of Cowles (1933).[13] As noted by Dimson and Mussavian (1998), whilst Bachelier (1900) first modeled the formulation for a random walk in security prices, it was not until the 1960s theoretical framework for the random walk developed by Samuelson (1965). Early statistical studies by Working (1934), Cowles and Jones (1937), Kendall (1953), Cootner (1962), Osborne (1962), Granger and Morgenstern (1963), Fama (1965), among others, performed tests on the random walk hypothesis and found a supportive evidence of the random walk hypothesis that successive price changes are independent (Ball 1994). These empirical findings combined with the theory of Samuelson, published in his influential paper *"Proof that Properly Anticipated Prices Fluctuate Randomly"*, led to the efficient market

[12] On March 29, 1900, a Ph.D. thesis by Louis Bachelier entitled "Theory of Speculation" was accepted by the Faculty of Sciences of the Academy of Paris, which eventually laid the foundation for the random walk hypothesis of market efficiency. (Dimson and Mussavian 1997)

[13] See, e.g., Fama (1970), Leroy (1989), Dimson and Mussavian (1997).

hypothesis (EMH). According to this hypothesis, in an informationally efficient market price changes must be unforecastable if they fully incorporate the expectations and information of all market participants. Since news is announced randomly, prices must fluctuate randomly. Consequently, it states that it is not possible to exploit any information set to predict future price changes. (Campbell et al. 1997, 20)

Another influential paper Fama (1970) reviewed the theoretical and empirical literature on EMH to that date. Fama (1970) formalizes this hypothesis further and indicates that a market is called efficient if prices "fully reflect" all available information. (Findlay and Williams 2000) Fama (1970) determines three sufficient conditions for the existence of capital market efficiency. Firstly, he names the absence of transactions costs. Secondly, he assumes all relevant information is available to all market participants without cost. Thirdly, on the implications of current information for the current price and distributions of future prices of each security, the current price of security should "fully reflect" all available information. These conditions ensure that investors possessing available information cannot earn above-competitive returns. A violation of any of the conditions does not necessarily imply inefficiency. The market "may be efficient if sufficient numbers of investors have ready access to available information" (Fama 1970). The violations of these conditions, however, may suggest impeding efficient adjustment prices to information. (Ball 1994; Fama 1970)

Crediting Roberts (1959)[14], Fama (1970) also distinguishes three forms of the efficient market hypothesis. A market is called weak efficient, if all the information regarding past price movements is reflected in the current stock price. Under this form, the information set is just historical prices that should offer no prediction of future changes in prices. In this case, no charts or

---

[14] Roberts (1959) was the first who originally introduced levels of market efficiency.

analysis based only on past prices can help to achieve abnormal profits. In other words, no profits are left unexploited; consequently, the result is a fair game[15] in the end. Secondly, a market is called semi-strong efficient, if all publicly available information is reflected in the stock price. Thus, one cannot make abnormal profits by using publicly known information. Finally, a market is called strong-form efficient if on the basis of all available information, including inside information, it is not possible to forecast future price movements. Semi-strong efficiency implies weak-form efficiency. Strong efficiency implies semi-strong and weak efficiency. If the weak-form of the EMH can be rejected, then also the semi strong and strong-form of the EMH can be rejected. (Campbell et al. 1997, 22; Fama 1970)

3.2.2 Definitions of Efficient Market

The available theoretical and empirical findings represent different stages of the development of the concept and reflect various views of researches. In the process of development of capital market efficiency into modern form, it is possible to recognize two different approaches. Fama's approach is referred to as the "empirical" tradition of Chicago school, which developed earlier formal foundations of EMH.[16] (Findlay and Williams 2000) The "information" economics approach was followed in works of Rubinstein (1975), Beaver (1981), and Latham (1986), who introduced alternative definitions. Approach of Fama concentrated to explain how the market uses information or establishes prices, whereas "information economics" school attempted to formalize the EMH considering individual investors and their relation to prices. Beaver (1981) defines market to be efficient with respect to information signal if it generates security prices identical to those that would be generated in a

[15] Under a fair game, on average, expected return on an asset equals its actual return (see, e.g., Fama 1970)

[16] In this view, individual beliefs that may be homogenous are not given importance. Investor who determines the price is informed and rational (Ball 1994).

market where each individual investor knows the signal, given preferences and endowments are identical in both markets. Latham (1986) defines efficiency relative to some information set that if revealed to all investors, would not change prices and portfolios. As pointed by Ball (1994) more formal definitions over Fama's model, are of limited use for empirical researches. The "identical world" where all investors assumed costlessly possess available information, however, in the real word it is impossible expected that all investors being costlessly and fully informed about all information. (Ball 1994) Therefore, any test of efficiency has to assume an equilibrium model, which was proposed by the "empirical school".

Fama's definition that in an efficient market, prices "fully reflect" available information was criticized by Leroy (1989) as empty and tautological. He argues that it is unclear how the market correctly uses all relevant information in determining security prices, if investors have heterogeneous information (Leroy 1989).

In the sprit of information economics approach Grossman (1976), also notices a paradox in Fama's definition of fully reflect. If prices fully reflect all available information, there is no reason for an investor to search for information in his decision-making of buying and selling different stocks. How could the prices fully reflect the information if no one searched for information? Grossman and Stiglitz (1980) analyzed this paradox and presented the model where the prices partially reflect the information that arbitrageurs possess. Their theory was based on two types of investors, informed and uninformed. If the market is efficient, where information is associated with a cost, the informed individuals would not able to get any compensation from the uninformed individuals, since the information will be fully reflected in the stock prices. However, they also found certain noise in this model, which implied that stock prices could not reflect all information. If the market price were perfectly informative, there would be little incentives for investors to search and pay for additional information for their decision-making. (Grossman and Stiglitz 1980; Latham 1986) This work has led the development of a large body of literature attempted to redefine the notion of the efficient markets (Findlay and Williams 2000).

More recently, Malkiel (1992) extends Fama's definition by including two dimensions: in efficient markets, security prices would be unaffected by revealing that information to all participants. Second, it is impossible to make profit by trading on this set of information. Therefore, the market efficiency can be judged by measuring profits made by trading on the information. This view is a closely related definition of market efficiency provided by Jensen (1978) (Campbell et al. 1997, 22; Timmermann and Granger 2004). However, their definitions concerns with information and transaction costs, but does not involve testing joint hypothesis[17] (Pesaran 2005).

Based on above different definitions, we may conclude that even if there are various critics toward Fama's definition and redefinitions of the concept, his definition of efficient markets is still the most commonly used standard and benchmark for determining market efficiency and relative market efficiency.

3.2.3 Model of the Efficient Market Hypothesis

The theoretical foundations for the efficient market hypothesis rest on the following three arguments:

1. **Investor rationality.** Investors are assumed to be rational, which means that they correctly update their beliefs when new information is available.

[17] Joint hypothesis problem means that even if the hypothesis of efficiency is rejected, it could either be because the market if truly inefficient, or because the equilibrium model has been assumed incorrectly (Campbell et al. 1997, 22).

2. **Arbitrage.** Even if not all investors are rational, some rational investors use arbitrage to remove pricing errors, so the average investor would not matter; the marginal investor sets prices.

3. **Collective rationality.** The random errors of investors cancel out in the market. Some investors are not rational, they trade randomly and, consequently, their trades cancel each other without affecting the prices.[18]

The rational investors value each security for its fundamental value defined by the net present value of its future cash flows discounted by a risk factor. This implies that the security prices fully reflect all the available information, and consequently, that in the prices formation all the relevant information is valued properly. This strong version of the efficient market hypothesis could be true only if the information and trading costs are always equal to zero. Hence, in this case there would not be a financial incentive to pay for information as it were already fully reflected in the asset prices. A weaker, but more realistic, version of the efficient market hypothesis is that the prices reflect the information until the point in where the marginal benefits of acting on the information (the expected profits to be made) do not exceed the marginal costs of collecting it (Jensen 1978). If investors are not fully rational, the efficient market hypothesis continues to have its value, and consequently, the prices fully reflect the fundamental value. Even if there is a high number of irrational investors, and their trading strategies are uncorrelated; their trades are likely to cancel each other having no effect on the market, where the asset prices will continue to be valued consistently with the fundamentals. (Pesaran 2005)

Assumption within the efficient markets hypothesis, market participants rationally formulate their buying and selling decisions based on available information about prices of financial assets and their relevant determinants.

[18] See Pesaran (2005).

Economic agents are therefore assumed to behave as if they formed their subjective expectations as the mathematical expectations of the true model of the economy. The efficient market hypothesis includes the joint hypothesis of a particular equilibrium model of returns together with the assumption of rational expectations. The doctrine of rational expectations was introduced by Muth (1961) supposed that the way to ensure rationality of expectations was require of them to be consistent with the models used to explain behavior of economic agents. (Cuthbertson 1996, 102) Formally, if $f(X_{t+1}|\Omega_t)$ is defined as conditional density function for the random variable X_t given the information Ω_t available at the time *t* then

$$E(X_{t+1}|\Omega_t) = \int_{-\infty}^{\infty} X_t f(X_t|\Omega_t) dX_t \tag{1}$$

is the conditional expectation corresponding to this density function. An error of a forecast can defined as $\varepsilon_{t+1} = X_{t+1} - E(X_{t+1}|\Omega_t)$. The error has two main properties:

1) $E(\varepsilon_{t+1}|\Omega_t) = 0$, which states that the expectation of a forecast error (conditional on the information available at time *t*) is zero;

2) $E(\varepsilon_{t+1}\Omega_t|\Omega_t) = 0$, which states that forecast errors are uncorrelated with any information available to economic actors

In order to prove or disprove the efficient market hypothesis, a model of returns must be specified against which the actual returns can be compared. If abnormal returns are found be unforecastable or random, the EMH is not rejected. Under the EMH, the return of an asset R_t incorporates risk and all relevant information. If current and past information are taken into account to reflect returns, correspondingly changes in return should occur with the availability of new information. Since new information or news is unpredictable, likewise with changes of return. Forecast errors are zero on average and independent from the set of information Ω_t available at time *t*, which is known as the orthogonality property. (Cuthbertson 1996, 105-106) Hereby the EMH is based on rational expectations:

$$R_{t+1} = E_t\left[R_{t+1}\right] + \varepsilon_{t+1} \quad \text{(2a)}$$

where the actual return of an asset R_{t+1} equals its expected return $E_t[R_{t+1}]$ plus a forecast error or (unexpected return on holding the asset) ε_{t+1} with

$$E_t\left[\varepsilon_{t+1}\right] = 0 \quad \text{(2b)}$$

Forecast errors are independent, identically distributed, and serially uncorrelated, which implies that the forecast error ε_t has no predictable effect on the forecast error of next period ε_{t+1}.[19] The orthogonality property can violated if forecast error ε_t is find to be serial correlated. The first-order autoregressive process is an example of a serial correlated error term. It is necessary to clarify that the equation (2b) implies that fair game[20] property for unexpected return is part of the EMH. (Cuthbertson 1996, 95; Taylor 2005, 31) A formal definition of the EMH can derived from the above equations by employing the accuracy expectations to define market efficiency:

$$f^p\left(R_{t+1}\middle|\Omega_t^p\right) = f\left(R_{t+1}\middle|\Omega_t\right) \quad \text{(2c)}$$

where market participants *p* know all the relevant information, i.e., $\Omega_t^p = \Omega_t$, and also know the complete probability density function of the possible

[19] This is defined as a strict white noise (see Taylor 2005, 31)

[20] The fair game model simply states that there is impossible to use information available at time *t* to earn a return greater than that which is consistent with risk relate in the security. (Fama 1970)

outcomes for returns. The superscript *'p'* implies that the expectations and forecast errors are conditional on the equilibrium model of returns used by investors. The expected return contains an element to compensate for systematic risk in the market and to enable investors to earn normal profits. (Cuthbertson 1996, 105)

Since testing for the random walk hypothesis is part of testing for the weak-form efficiency under the efficient market hypothesis, we continue to present a general formulation of random walk model. A random variable defined at discrete times follows a random walk if its expected value in the next period is the same as its most recent value. A stochastic variable *X* is said to follow a random walk if

$$X_{t+1} = \delta + X_t + \varepsilon_{t+1} \tag{3}$$

with δ being a drift parameter and the forecast error ε_{t+1} being identically and independently distributed. A random walk without drift has $\delta = 0$. The random walk is more restrictive than the fair game of (2b) and the martingale since it requires the higher moments of distribution to be statistically independent. The martingale X_{t+1} condition, unlike random walk model, does not restrict the non-linear dependence of second moments, so that with martingale process stock price changes are unpredictable while the second moment could exhibit dependence.[21] Therefore, the empirical literature on predictability of the stock returns tests for the stochastic properties of stock returns, which could be a random walk or martingale process and do not violate the efficient market hypothesis. Furthermore, a random walk process is non-stationary, which easily leads to spurious results unless stationarity is established by means of integrating. If stock prices follow random walk, this would imply that the

---

[21] A stochastic process X_t is a martingale with information set Ω_t, if the best forecast of X_{t+1} based on current information Ω_t would be equal to the current value X_t or formally: $E(X_{t+1}|\Omega_t) = X_t$ (Cuthbertson 1996, 102-103).

market is efficiently weak-form. Yet, the opposite does not necessarily hold true, as the definition of market efficiency given in (2c) imposes restriction on the behavior of the first moment ε_{t+1} only. (Cuthbertson 1996, 104)

3.2.4 Empirical Evidence on Efficient Market Hypothesis

Nearly all of the empirical research on theory of the efficient markets has been concerned with whether prices “fully reflect” particular subset of available information (Fama 1970). Particularly, the empirical studies on this matter have been divided in tests on the weak, semi-strong and strong-form of the efficient market hypothesis.

Most early empirical works have presented evidence supporting the weak-form of market efficiency. The origins of these researches lay mainly in the random walk literature. Studies have attempted to test this hypothesis by examining the correlation between the current return on a security and the return on the same security over a previous period. If the random hypothesis were true, then correlation would expect to be zero. Cowles and Jones (1937) develop one of the first tests of the random walk hypothesis (RWH). The result of their study does not support the RWH because of the acknowledged error in their analysis. According to Fama (1970), earlier works of Kendall, Workings and Roberts found series of speculative price changes to be linearly independent as measured by autocorrelation, and that these series may be defined by random walks. Similar results was found by Osborne (1959), Cootner (1962), Fama (1965), Fama and Blume (1966). (Dimson and Mussavian 1998)

Osborne (1959) attributed an economic rationale behind the independence of successive price changes. His rationale claims that the decisions of investors in an individual security are independent, which is one reason why we see independent price changes. (Fama 1970) Cootner (1962) observes that price changes result from the emergence of new information. Since information is random in appearance, then stock price movements should follow a random walk, which indicates that they are statistically independent. (Leroy 1989)

Fama (1965) applies serial correlation test, runs test and Alexander's filter rule technique to daily data of 30 individual stocks quoted in the Dow Jones Industrial Average for the period from 1956 to 1962. He found a very small positive correlation, which was not statistically different from zero, while the number of runs was smaller than expected which indicates that the positive correlation found by the serial correlation test. Both tests show that the independence in successive price changes is either extremely small or non-existent. The results of filter rule technique also show no profitability. Hence, Fama conclude the DJIA to be weak-form efficient.

Another strand of literature tests the weak-form efficiency by examining the gains from technical analysis. Alexander (1965) has shown that the certain filter strategies could not generate abnormal profits after transaction costs were taken into account. The results of Fama and Blume (1966) provide further evidence of no profitability of filters relative to buy-and-hold strategies. Until the 1990s, Fama and Blume (1966) remained the best-known and most influential paper on mechanical trading rules. Their results caused academic skepticism concerning the usefulness of technical analysis. (Campbell et al. 1997, 42-43)

The initial tests also supported semi-strong form of efficient market hypothesis. Testing semi-strong form of market efficiency was initially carried out in the form of event studies (Fama 1991). The empirical tests were concerned with speed and correctness of price adjustment to new events and or information such as stock splits or earnings announcements. The pioneers on this kind of study were Fama et al. (1969). They studied the reaction of

940 stocks to split announcements and concluded that market prices adjusted correctly to the information implicit in a split. (Findlay and Williams 2000) Ball and Brown (1968) examine the effects of annual earning announcements. They found that investors were unable to trade profitably on the basis of announcements since the relevant information had already been reflected in the stock prices by the time of an announcement. Since the first event studies, many other studies have continued to valuing a multitude of important news events such as dividend announcements, takeovers, repurchases, share issues and so on. (Dimson and Mussavian 1998; Fama 1970)

While evidence convincingly supports weak and semi-strong form efficiency, evidence for strong-form efficiency remains to be questionable. Empirical tests of strong form efficiency are focused on two issues: whether insider trading results in abnormal returns or if professional investors, analysts and managers have profitable information. (Fama 1991, Fama 1970) Niederhoffer and Osborne (1966) have shown that the specialists on the NYSE evidently use their monopolistic access to information about unfilled limit orders to obtain superior returns. A similar result provided by Scholes (1972) also argues that officers of corporations might have monopolistic access to information about their firms. (Fama 1970) Jaffe (1974) finds considerable evidence that insider trades are profitable. Jensen (1968) investigated fund managers' performance using 115 mutual funds over the period 1955-1964 and shows that funds on average were unable outperform the naïve strategy. (Dimson and Mussavian 1998)

Later empirical work generated the results were not much consistent with earlier findings. Since the late 1970s, a large number of studies have provided evidence theoretical and empirical challenges to the efficient market hypothesis. Contrary to the EMH predictions, recent empirical results have shown that stock returns to be partially predictable and non-normally distributed. Recent literature reports evidence against the random walk hypothesis for stock returns (Poterba and Summers 1986; Fama and French 1988; Lo and MacKinlay 1988). A number of studies find the evidence inefficiency consistent with the weak form of efficient market hypothesis, these researches includes excess volatility (Shiller 1981), momentum effect (Lehman 1990; Jegadeesh and Titman 1993), overreaction (Debondt and Thaler 1979), mean reversion (Fama and French 1988; Poterba and Summers 1986), and anomalies (Lakonishok 1988; French 1980; Ariel 1990). Whereas major studies also show inefficiency consistent with semi-strong form of efficient market hypothesis, these studies concentrate such as on size effects and January effects (Fama and French 1993). (Fama 1991; Fama 1998; Malkiel 2003)

3.3 Review of Literature on Weak-Form Market Efficiency

The earlier tests of the weak-form of efficient market hypothesis are concerned with the predictability power of past returns. It indicates that future returns cannot be forecasted from past returns data since the current returns are considered to contain all information that is incorporated in historic data. Fama (1991) has extended the coverage from the predictability power of past returns only to the general area of tests for return predictability, which also covers seasonal in returns and the forecasting ability of variables like dividends, firm size and or interest rates. Following by Fama's theory and comprehensive empirical work of efficient capital market a plethora of studies were devoted to testing validity of the weak form of the EMH. A large number of these researches has centered on developed markets.

3.3.1 Evidence from Developed Markets

Empirical studies test the EMH in terms of the null hypothesis that there is no serial correlation. In the short-run, when stock returns are measured over periods of days or weeks, the general evidence against market efficiency is a presence of positive correlation in stock returns. However, recent studies on autocorrelation in stock returns have shown mean reversion in stock prices. (Engel and Morris 1991) Fama and French (1988) show that for the United States there is significant negative serial correlation in long horizon returns. Similarly, Poterba and Summers (1986) find positive serial correlation at short horizons and negative serial correlation at long horizons in the United States and 17 other countries. Positive autocorrelation infers predictability of returns in the short horizon, whereas negative autocorrelation reflects predictability in the long horizon (Fama 1991).[22]

Earlier empirical examination of the EMH were mainly based on serial correlation and runs tests, more recent tests of market efficiency have used variance ratio test. Variance ratio test originated form the pioneering works of Lo and MacKinlay (1988) and Cochrane (1988). Using a simple specification test based on variance estimator Lo and MacKinlay (1988) examine 1216 weekly observations derived from the Center for Research in Security Prices (CRSP) daily returns file for the period September 6, 1962 to December 26, 1985. Their results reject the random walk hypothesis for the entire sample period (1216-week) and for all sub-periods (608-week) for returns indexes and size-sorted portfolios.

In contrast to the negative serial correlation that Fama and French (1988) found for longer-horizon period, Lo and MacKinlay (1988) find significant positive serial correlation for weekly and monthly holding-period returns. Fama and French (1988) show that long holding-period returns are significantly negatively serially correlated, indicating that 25 and 40 percent of the variation of longer-horizon return is predictable from past returns. On the other hand, similar to Poterba and Summers (1986) and Fama and French

[22] If share prices are mean reverting, then long-horizon returns are negatively autocorrelated (Lo and MacKinlay 1988).

(1988), Lo and MacKinlay (1988) find the evidence against the EMH in stock prices of small firms but not for large firms. Lo and MacKinlay (1988) also argue that the rejection of random walk hypothesis cannot be explained completely by infrequent trading or time varying volatilities, although the rejections are due largely to the behavior of small stocks. Contrary to results of Fama and French (1988), Lo and MacKinlay (1988) also assert that the rejection of random walk for weekly returns does not support a mean reverting model of asset prices.

Lee (1992) employs variance ratio test to examine whether weekly stock returns of the United States and 10 industrialized countries: Australia, Belgium, Canada, France, Italy, Japan, Netherlands, Switzerland, United Kingdom, and Germany follow a random walk process for the period 1967-1988. He finds that the random walk model is still appropriate characterization of weekly return series of for majority of these countries.

Choudhry (1994) investigates the stochastic structure of individual stock indices in seven OECD countries: the United States, the United Kingdom, Canada, France, Germany, Japan and Italy. The Augmented Dickey-Fuller and KPSS unit root tests, and Johansen’s cointegration tests was used to test the log of monthly stock indices from the period 1953 to 1989. He concludes that stock markets in seven OECD countries are efficient during the sample period. Their result from both unit root tests show that all seven series seem to contain a stochastic trend (unit root) and they are non-stationary in levels. The result of Johansen’s cointegration test shows no support for a stationary long-run relationship between the seven stock series. Absence of long-run multivariate relationships also provides evidence of efficient markets.

Using Phillips-Peron (PP) unit root and Johansen’s cointegration tests, Chan et al. (1997) tested for the weak-form and the cross-country market efficiency hypothesis of eighteen international stock markets. The markets included are

Australia, Belgium, Canada, Denmark, Finland, France, Germany, India, Italy, Japan, Netherlands, Norway, Pakistan, Spain, Sweden, Switzerland, the United Kingdom, and the United States. Their data covers the period from January 1962 to December 1992, with 384 monthly observations for each of the stock series. In their studies, these markets were analyzed both individually and collectively in regions to test for the weak form efficiency. Chan et al. (1997) conclude that all stock market examined are individually weak form efficient and only a small number of stock markets show evidence of cointegration with others.

Huang (1995) examine efficiency of nine Asian stock markets: Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Thailand and Taiwan by using the variance ratio statistic with both assumptions homoscedastic and heteroskedastic. His data consist of weekly stock returns of nine stock market indexes from the period 1988 to 1992. Excluding the market in Indonesia, Japan and Taiwan, the random walk hypothesis for the remaining markets is rejected. The result of variance ratio exceeds one in the markets of Korea, Malaysia, Hong Kong, Thailand and Philippines, indicating the presence of positive serial correlation. The hypothesis for markets of Korea and Malaysia is rejected for all holding periods, whereas the hypothesis for the Hong Kong, Singapore, and Thailand markets is also rejected but in using the heteroscedasticity-consistent variance ratio estimator.

Al-Loughani and Chappel (1997) examine the validity of the weak-form of efficient market hypothesis for the United Kingdom stock market using the Lagrange multiplier (LM) serial correlation, Dickey-Fuller unit root and Brock, Dechert and Scheinkman (BDS) non-linear tests. Their data include daily observations of Financial Times Stock Exchange (FTSE) 30-share index from the period June 30, 1983 to November 16, 1989, a period that they describe as free of changing government economic policy toward financial markets. The result of Dickey Fuller tests show that series are non-stationary in levels and are stationary in first differences, which are consistent with random walk hypothesis. However, based on the BDS and serial correlation tests, they reject the random walk hypothesis finding autocorrelation and conditional heteroskedasticity in the FTSE 30 returns. Therefore, according to their results the series of FTSE 30-share index does not follow a random walk during the sample period.

Groenewold (1997) examines both weak and semi-strong forms of the EMH for Australia and New Zealand using daily observations on the Statex Actuaries' Price Index for Australia and the NZSE-40 Index for New Zealand covering the full 1975-1992 sample period. Weak form efficiency tested using the Dickey -Fuller and Phillips-Peron unit root tests, variance ratio and autocorrelation tests, and semi-strong efficiency tested using both cointegration and Granger causality tests. The results of unit root tests show that both indexes were consistent with the non-stationary implications of the weak form of the EMH, whereas the autocorrelations provide evidence of return predictability. However, he finds that degree of predictability of returns is not high, that 24 lagged returns being only little over 5%. Moreover, the result of variance ratio does not reject the random walk hypothesis in both markets. Therefore, he argues that taken as evidence against the weak form of the EMH is not altogether clear. The two countries' indexes were found not to be cointegrated, which is consistent with market efficiency, but however, the Granger causality were enable to reject, which is evidence against the EMH. With regard to all results, Groenewold (1997) concludes that past returns in both countries might help to explain the current return in each, but the proportion of variation explained is still small.

Worthington and Higgs (2004) test for random walks in sixteen developed markets: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom, and four emerging stock markets: Czech Republic, Hungary, Poland and Russian. They use daily returns of market value-weighted equity indices in US dollars from period for sixteen developed markets from December 31, 1987 to May 28, 2003, and for four emerging stock markets from December 30, 1994 to May 28, 2003. Using various methods including serial correlation, runs, three types of unit root (Augmented Dickey-Fuller, Phillips-Perron and KPSS) and multiple variance ratio tests[23], they show that the random walk hypothesis is not rejected in major European developed markets.

Worthington and Higgs (2004) find that Germany and Netherlands are weak-form efficient under both serial correlation and runs tests, while Ireland, Portugal and the United Kingdom are efficient under one test or the other. Thus, rests of the markets do not follow a random walk. The ADF and Phillips-Perron unit root tests reject the null hypothesis in the all twenty emerging and developed markets, while the KPSS unit root tests fail to reject the null hypothesis excluding the Netherlands, Portugal and Poland. From the variance ratio test, the null hypotheses of homoscedastic and heteroskedastic are not rejected in the United Kingdom, Germany, Ireland, Hungary, Portugal and Sweden. The rejection of the null hypothesis of the homoscedastic but not the heteroskedastic random walk is found for France, Finland, Netherlands, Norway and Spain. The most restrictive notion of a random walk indicates that it is not possible to predict either future price movements or volatility on the basis of information from past prices is found to be in Germany, Ireland, Portugal, Sweden and the United Kingdom. France, Finland, Netherlands, Norway and Spain satisfy at least some of the requirements of a strict random walk. Among the emerging markets, only Hungary satisfies the strictest requirements for a random walk in daily returns.

[23] The multiple variance ratio test proposed by Chow and Denning (1993) expanded the methodology based on Lo and MacKinlay's single variance ratio test. They adjust focus of tests from the individual variance ratio for a specific interval to one more consistent with the random walk hypothesis by covering all possible intervals.

Using variance ratio of Lo and MacKinlay and multiple variance ratio methods Lima and Tabak (2004) find that the random walk hypothesis for Hong Kong equity markets is not rejected, but for Singapore markets is rejected. Their data covers daily returns of the Hang Seng Index for Hong Kong and the Straits Time Index for Singapore from the period June 1992 to December 2000. Using variance ratio method Cheung and Coutts (2001) also confirm that Hang Seng follows a random walk hypothesis. They use daily closing prices of the Hang Seng Index from January 1985 to June 1997, giving 3561 observations.

3.3.2 Evidence from Emerging Stock Markets

Emerging stock markets have recently attracted increasing attention from both researchers and investors. The great interest is not surprising because during early nineties growth of emerging markets are remarkable. Besides its phenomenal growth, emerging market attracts their low correlation with major developed stock markets, and also stock returns in many emerging markets are noticeable more predictable than developed stock markets because of exhibiting systematic patterns. Harvey (1995) studied volatility and returns predictability of six Latin American, eight Asian, three European and two African emerging stock markets and found presence of strong serial correlation in the stock returns which cause them more predictable. Due to recent liberalization in many developing countries, increasing studies have focused on predictability of return behavior and major of the studies on examining the validity of random walk hypothesis in the emerging stock markets.

Laurence (1986) applies both the runs and autocorrelation test on the Kuala Lumpur Stock Exchange (KLSE) and the Stock Exchange of Singapore (SES). He uses price observations of the individual stock from the period 1973 to

1978 for both KLSE and the SES. The results of both tests suggest that both markets are not weak form efficient. Contrary to his results, Barnes (1986) finds KLSE to be weak form efficient. He conducted a similar method of testing applied to 30 companies and six sector indexes for the six years period ended 1980. Barnes (1986) concludes that the results of both tests show that the KLSE exhibit a high degree of efficiency in the weak-form.

Parkinson (1987) tested the validity of the weak-form efficiency of the Nairobi Stock Exchange using monthly prices of individual companies for the period 1974 to 1978. The result of the runs test show that the 50 companies in NSE, 49 exhibited fewer numbers of the runs that expected. Therefore, the hypothesis of random walk is rejected for these data. Dickinson and Muragu (1994) also examine Nairobi Stock Exchange using the autocorrelation and runs tests. The period of their data continues the work of Parkinson, starting in the 1979 and ending in the 1989. Their data include weekly prices of the 30 most actively traded stocks. Contrary to Parkinson (1978), Dickinson and Muragu (1994) find that the results support the weak-form of efficient market hypothesis in NSE.

Urrutia (1995) employs both variance ratio of Lo and MacKinlay (1988) and runs tests to investigate random walk for the four Latin American emerging markets. He uses monthly data of index prices in local currency from the period December 1975 to March 1991 for Argentina, Brazil, Chile, and Mexico. The variance ratio test rejects the random walk hypothesis for all the four markets, while runs test does not. Based on results from the runs test, he concludes that the four Latin American emerging stock markets are weak-form efficient.

Ojah and Karemera (1999) tested random walk for the same four Latin American markets as Urrutia (1995) did. They apply single variance ratio of Lo and MacKinlay (1988), multiple variance ratio of Chow and Denning

(1993), and runs tests to monthly national stock price indexes in U.S. dollar terms for the period December 1987 to May 1997. Under the single variance ratio test, except Argentina, rest of the three markets including Brazil, Chile and Mexico do not follow a random walk. However, the result of multiple variance ratios indicates that all the four market follow a random walk, whereas the runs tests reject the random walk hypothesis for Chile, but not Argentina, Brazil and Mexico. Similar to Urrutia (1995), Ojah and Karemera (1999) conclude that four Latin American emerging markets are weak-form efficient.

Karemera et al. (1999) examine the random walk hypothesis for fifteen emerging stock markets using similar statistical tests as Ojah and Karemera (1999) did. Their data comprises monthly national stock price indexes expressed in both local currency and the U.S. dollars for the period 1986 to 1997. They observe that local currency-based data provide different result compare with return series expressed in U.S. dollars. With U.S. dollar based data, results of 10 of the 15 emerging stock markets they examined are consistent with the random walk hypothesis under the multiple variance ratios, while 5 of the 15 are consistent the random walk hypothesis under the single variance ratio. With local currency-based data, results of 10 (Indonesia, Israel, Jordan, Korea, Malaysia, Mexico, Philippines, Taiwan, Thailand, and Turkey) of the 15 markets follow a random walk under the multiple variance ratios, while six (Israel, Jordan, Malaysia, Mexico, and Taiwan) of the 15 follow a random walk under the single variance ratio. However, results on Argentina, Brazil, Hong Kong, Indonesia, Mexico, Philippines, Singapore, Taiwan, and Turkey equity returns are not consistent under two different currency-based data. Their results of runs test show that the hypothesis of independence cannot be rejected at 5% level of significance for nine of the 15. Hereby six markets including Chile, Israel, Philippines, Singapore, Taiwan, and Thailand are not weak form efficient based on U.S. dollar data. Therefore, their results support the evidence provide by Urrutia (1995) who finds Argentina, Brazil and Mexico to be weakly efficient. With local currency-based data, 12 of the 15 emerging markets are weak form efficient, only Argentina, Chile and Singapore are found not to be weak-form efficient.

Chang et al. (1996) tested the weak form of the EMH using monthly data on the Taiwan stock exchange from 1967 to 1993. Employing the Ljung-Box Q, the runs and the unit root tests, they observe that the Taiwan stock market is weak-form efficient. Using the variance ratio test, Chang and Ting (2000) also examine the validity of weak form efficiency of the Taiwan stock market for the period 1971-1996 and conform to the findings of Chang et al. (1996). Chang and Ting (2000) use the weekly, monthly, quarterly and yearly returns of the value-weighted stock price index. Their results reject the random walk hypothesis with weekly returns, but not with monthly, quarterly and yearly value-weighted market indexes.

Antoniou et al. (1997) use daily stock prices of the ISE Composite Index for the period 1988 to 1993 to examine the weak form efficiency for the Istanbul Stock Exchange (ISE). Observing that thin trading may lead to serial correlation in the return series, Antoniou (1997) carry out the analysis for both unadjusted and adjusted for thinness returns using a method proposed by Miller et al. (1994). Thin or infrequent trading occurs when stock do not trade at every consecutive interval. Miller at al. (1994) model suggests that to remove the impact of thin trading a moving average model (MA) that reflects the number of non trading days should be estimated and then returns be adjusted accordingly. Despite the improvement with adjusted returns, they find serial dependence in returns. Therefore, according to their results the ISE is weakly inefficient. Recently Tas and Dursonoglu (2005) have confirmed the inefficiency result for Turkey using daily stock returns of ISE 30 indices from the period 1995 to 2004. Dickey-Fuller unit root and runs tests were used in their studies and the results of both tests reject random walk hypothesis in ISE.

In the Middle East, Butler and Malaikah (1992) examine weak-form efficiency for the Kuwait and Saudi Arabian stock markets by using autocorrelation test. Their data covers daily stock returns of two stock markets for the period 1985 to 1989. They find evidence of efficiency in Kuwait stock market, but not in the Saudi Arabian market. Similarly, Abraham et al. (2002) study weak-form efficiency in three major Gulf stock markets including Kuwait, Saudi Arabia, and Bahrain using the variance ratio and runs tests for the period October 1992 to December 1998. Their data consist of weekly index values for each of three Gulf stock markets. The results of both tests reject the random walk hypothesis in all markets. Taking into consideration on possible infrequent trading in all three markets, they apply a correction to the observed index by using decomposition of index returns introduced by Beverigde and Nelson (1981). After the correction, they fail to reject the random walk hypothesis for the Saudi Arabia and Bahrain markets, but not for the Kuwait market.

Using a similar method as Antoniou et al. (1997), Hassan et al. (2003) observe that the Kuwait stock market (KSE) is weak-form inefficient. Taking into consideration possible thin trading and nonlinearity characterize the Kuwait markets, they use method proposed by Miller et al. (1994) to correct for possible thin trading, and a logistic map model[24] to account for possible non-linearity in the generating process of return. They also employ GARCH-M and EGARCH models to examine whether the pattern predictability is evident where a measure of time varying risk parameter is included in the model. Their data include series of daily stock price index for period 1995 to 2000. Their results do not support the null hypothesis of market efficiency for the whole sample period. According to them, possible reasons for inefficiency is because of thinly trading in the most of the stocks in Kuwait Stock Exchange

[24] A logistic map is type of nonlinear function that maps the price of an asset at time *t*-1 to the price at time *t* (Appiah-Kusi and Menyah 2003). For further details see, e.g., Antoniou et al. (1997).

and the fact that their study covers the aftermath of various important regulatory reforms carried out in the KSE.

Moustafa (2004) examines the behavior of stock prices in the United Arab Emirates (UAE) stock market using daily prices of 43 stocks included in the UAE market index for the period October 2, 2001 to September 1, 2003. He finds that the returns of the 43 stocks do not follow normal distribution. However, the results of runs tests show that the returns of 40 stocks out of the 43 are random at 5% level of significance. Although the UAE stock market is newly developed and it is still very small, also suffering from infrequent trading, according to his results, the UAE is found to be weak-form efficient.

Appiah-Kusi and Menyah (2003) tested out the weak-form efficiency of eleven African stock markets including Botswana, Egypt, Ghana, Ivory Coast, Kenya, Mauritius, Morocco, Nigeria, South Africa, Swaziland, and Zimbabwe by accounting for thin trading in the calculation of returns, and allowing for nonlinearity and time-varying volatility in the return generation process. They use weekly data of index prices in local currency for the period 1989-1995, and apply Miller et al. (1994) model, a logistic map and EGARCH-M model to test efficiency of all the eleven markets. Their results indicate that except the markets in Egypt, Kenya, Mauritius, Morocco, and Zimbabwe, rest of the six markets are found not to be consistent with weak form efficiency. In addition, they find that the return generation process is nonlinear in all the eleven markets, and in five of the market, investors demand a time-varying risk premium for the risks they bear. In particular, contrary to prior studies, they find Nigerian market not to be efficiently weak form. Yet their modeling approach produces a significant time-varying risk premium for the Nigerian markets that linear models would not have been able to capture. Consequently, they argue that efficiency test models that do not control for time-varying risk premium are likely to be using inappropriate models.

However, very recently Akinkugbe (2005) finds stock markets in Botswana to be weak and semi-strong form efficient. His data includes 738 weekly observations for the period June 1989 to December 2003. Autocorrelation, and Augmented Dickey-Fuller and Phillip-Perron unit root tests were used to investigate the weak form of EMH in Botswana stock exchange. In his study, autocorrelation test show evidence of no serial correlation and the results of both unit root tests indicate a stationary process for stock returns, therefore implying weak-form efficiency.

Poshakwale (1996) examines weak form efficiency and daily of the week effect on the Bombay Stock Exchange in India using daily BSE national data for the period January 1987 to October 1994. He finds that the frequency distribution of the prices in BSE does not follow a normal distribution. Furthermore, his results of runs and serial correlation tests also provide evidence on non-random behavior of stock prices in BSE. Poshakwale (1996) also finds evidence that the average returns are different on each day of the week, result show the returns achieved on Friday are significantly higher compared to rest of the days of the week. Consequently, he concludes that the Indian stock market is not weak-form efficient.

Using the serial correlation, runs and unit root tests Abeysekera (2001) indicates that the Colombo Stock Exchange (CSE) in Sri Lanka is weak-form inefficient. His data include daily, weekly and monthly returns of the Sensitive Share Index (based on market prices of 24 blue-chip companies listed on the CSE) and a 40-security value weighted index for the period January 1991 to November 1996. The results of three tests consistently reject the random walk hypothesis. Abeysekera (2001) also examines a day-of-the-week and a month-of-the-year effect on the CSE, but neither effect found to be on the stock market in Sri Lanka.

Mobarek and Keasey (2002) used the runs and autocorrelation tests to examine the validity of weak-form efficiency for the Dhaka stock market in Bangladesh. Their sample covers 2638 daily observations of daily price indices from the period 1988 to1997. The daily share price indices consist of all the listed companies stock. Based on the runs and the autocorrelation tests, he argues that returns of Dhaka stock market do not follow random walks.

Different results was found by Khaled and Islam (2005) on testing weak form efficiency of the Dhaka stock market using daily, weekly and monthly market prices from the period 1990 to 2001. Unit root and variance ratio tests were used to test for the random walk hypothesis in their studies. In addition, they examine the structural changes by applying the variance ratio test separately for the period before July 1996 when the Dhaka Stock Market boom started in July 1996 and for the period after March 1997 when crash in mid-November continued until March 1997. According to them, the hypothesis of market efficiency could not be rejected in the case of monthly data. For weekly data and daily data, however, market efficiency is rejected for the pre-boom period, not for the post-crash. In addition, they argue that by using heteroscedasticity of variance ratio test they find evidence in favor of short-term predictability of share prices in the Dhaka stock market before the 1996 boom, but not during the crash. Mobarek and Keasey (2002), however, find the market to be inefficient during the crash time. Khaled and Islam (2005) argue that the reason is stem for the fact that Mobarek and Keasey (2002) used the Box-Pierce *Q* which is less powerful test of autocorrelation in the presences of heteroskedastic errors.

Several other studies concentrate in European emerging markets. For example, Gilmore and McManus (2003) examine whether the stock markets in Central European countries including Czech Republic, Hungary and Poland are efficiently weak form using various tests including univariate methods (unit root, variance ratio, and autocorrelation), multivariate tests (Johansen and Granger causality) and model-comparison approach (Naïve, ARIMA and GARCH).[25] They use weekly Investable and Comprehensive indexes from the International Financial Corporation (IFC) for the period July 1995 through September 2000.

Gilmore and McManus (2003) show that results of the ADF and PP unit root tests indicate that all series are integrated of order $I(1)$. The Ljung-Box Q-statistics show that returns tend to be more significant for the Comprehensive series than for the Investable. They argue that might derive from the possible differences in behavior of internationally versus domestically traded stocks. The result of Q-statistics also show that over time all three markets are moving in the direction of lower levels of autocorrelations in returns, indicating efficiency improvement in these markets. The variance ratios under the assumption of heteroscedasticity fail to reject random walk hypothesis for either index for any of the three markets. Their the multivariate tests, however, show mixed evidence, with the Johansen cointegration test indicate the absence of a cointegration relationship between these markets, while Granger-causality were found to be running from the Czech and Hungarian market to the Polish exchange. They assert that the differences in privatizations methods and economic environments in the three countries may explain lack of cointegration during the period, and the Granger-causality may be due to the higher levels of foreign investment in the Czech and Hungarian markets, which would then influence the Polish market. In contrast with the univariate method findings, they find that model comparison approach provides strong evidence against the random walk hypothesis for these markets. They conclude that these three markets are not yet weak-form efficient.

---

[25] The idea of a model-comparison approach is that if stock prices follow a random walk, then a random walk (NAÏVE) model should not be out-predicted by other models (Gilmore and McManus 2003).

Smith and Ryoo (2003) investigate the random walk behavior in five European emerging markets using variance ratio tests. They employ weekly data of index prices in local currency for the period April 1991 to August 1998. According to their results, in four of the markets, Greece, Hungary, Poland and Portugal, the random walk hypothesis is rejected because returns have autocorrelated errors. The positive autocorrelation is found be in four of the markets, while in Turkey, the Istanbul stock market is found to follow a random walk. They claim that this might be deriving from the fact that the Istanbul stock market being larger and liquid compared with the other four markets. However, evidence from other studies, which use variance ratio tests, suggests that relatively large size on its own is neither necessary nor sufficient for a market to follow a random walk. Small markets, which are examined to follow a random walk, for example Argentina (Urrutia 1995; Ojah and Karemera 1999) and Indonesia (Huang 1995), and large market do not: Hong Kong and Korea (Huang 1995) and Mexico (Urrutia 1995).

Abrosimova et al. (2005) tested for weak-form efficiency in the Russian stock market using daily, weekly, monthly Russian Trading System (RTS) index time series from September 1995 to May 2001. Unit root, autocorrelation and variance ratio tests are employed to test null hypothesis of the random walk in their study. They also use model-comparison approach. With the ADF and the PP unit root tests, the RTS index series are found to be stationary difference. Results of both autocorrelation and variance ratio tests reject the null hypothesis of the random walk for the daily and weekly, but not for the monthly data. For monthly data, the variance ratio under the assumption of heteroscedasticity increments the null hypothesis of random walk cannot be rejected. Therefore, they study linear and non-linear dependence in the daily and weekly data using ARIMA and GARCH models. They find that none of the analyzed models outperformed others. They end up with evidence that support weak-form efficiency in the Russian stock market.

Hassan et al. (2006) conduct a test of efficiency in seven European emerging stock markets. They use International Finance Corporation's weekly stock index data for the period December 1988 through August 2002. Several methods used in their studies including Ljung-Box Q-statistic, runs, and variance ratio tests. According to their results, except Greece, Slovakia, and Turkey, markets in Czech Republic, Hungary, Poland and Russia are found to be unpredictable.

Overall, empirical results from both the developed and developing markets show contrasting evidence on weak form efficiency. Table 2 summarizes all results regarding a review of literature on market efficiency in developed and emerging markets in this study. Although recent studies have found developed markets not to be completely consistent with weak-form efficiency compare with early results, we can still make a conclusion about the fact that major empirical studies of developed markets support the random walk hypothesis and markets are mostly conclude to be at least weak-form efficient. However, a similar conclusion cannot make in the case of emerging stock markets.

The results of whether or not emerging markets follow random walks are rather conflicting. Mixed results from literature on emerging stock market efficiency are not surprising since it is observed that emerging stock markets are generally less efficient than developed markets. Emerging markets differ from developed countries in various ways. In comparative terms, while the developed markets with well-established institutions are characterized as having high level of liquidity and trading activity, substantial market depth and low information asymmetry, the emerging market are observed to exhibit more information asymmetry, thin trading and shallow depth because of their weak institutional infrastructure. (Khaled and Islam 2005) Despite the fact that emerging markets are characterized by these imperfections mentioned above, not all of the emerging markets are necessarily entirely inefficient. In fact, some researchers have found some of the larger and even smaller stock markets in developing countries to be weak-from efficient.

Table 2. Summary of Selective Empirical Studies on Weak-Form Efficiency in Developed and Emerging Stock Markets

Plus (+) sign indicates that the random walk hypothesis is not rejected, minus (-) sign indicates that the random walk hypothesis is rejected, and plus and minus signs together +(-) indicates the mixed results of rejecting the random walk hypothesis. Panel A shows the studies on developed markets and Panel B shows the studies on Emerging stock markets.

Study	Market	Sample	Results
Panel A: Developed markets			
Lo & MacKinlay (1988)	U.S.	1962-1985	-
Lee (1992)	U.S.,10 developed countries	1967-1988	+
Choudhry (1994)	U.S, U.K., Canada, France, Japan, Italy, Germany	1953-1989	+
Huang (1995)	9 Asian stock markets	1988-1992	+(-)
Al-Loughani & Chappel (1997)	U.K.	1983-1989	-
Chan, Gup & Pan (1997)	18 international stock markets	1961-1992	+
Groenewold (1997)	Australia, New Zealand	1975-1992	+(-)
Cheung & Coutts (2001)	Hong Kong	1985-1997	+
Worthington & Higgs (2004)	16 European markets	1987-2003	+
Lima & Tabak (2004)	Hong Kong, Singapore	1992-2000	+(-)
Panel B: Emerging markets			
Laurence (1986)	Singapore, Malaysia	1973-1978	-
Barnes (1986)	Malaysia	1974-1980	+
Butler & Malaikah (1992)	Kuwait, Saudi Arabia	1992-1998	-
Parkinson (1987)	Kenya	1974-1978	-
Dickinson & Muragu (1994)	Kenya	1979-1988	+
Urrutia (1995)	Argentina, Brazil, Chile, Mexico	1975-1991	+
Poshakwale (1996)	India	1987-1994	-

Table 2. (continued)

Study	Market	Sample	Results
Chang et al. (1996)	Taiwan	1967-1993	+
Antoniou et al. (1997)	Turkey	1988-1993	-
Karemera et al. (1999)	15 emerging stock markets	1986-1997	+
Ojah & Karemera (1999)	Argentina, Brazil, Chile, Mexico	1987-1997	+
Chang & Ting (2000)	Taiwan	1971-1996	+
Abeysekera (2001)	Sri Lanka	1991-1996	-
Mobarek & Keasey (2002)	Bangladesh	1988-1997	-
Abraham et al. (2002)	Kuwait, Saudi Arabia, Bahrain	1992-1998	+(-)
Appiah-Kusi & Menyah (2003)	11 African stock markets	1989-1995	+(-)
Gilmore & McManus (2003)	Czech Republic, Hungary, Poland	1995-2000	-
Smith & Ryoo (2003)	Greece, Hungry, Poland, Portugal, Turkey	1991-1998	+(-)
Hassan et al. (2003)	Kuwait	1995-2000	-
Moustafa (2004)	The United Arab Emirates	2001-2003	+
Worthington & Higgs (2004)	Czech Republic, Hungary, Poland, Russia	1994-2003	+(-)
Abrosimova et al. (2005)	Russia	1995-2000	+
Akinkugbe (2005)	Botswana	1989-2003	+
Khaled & Islam (2005)	Bangladesh	1990-2001	-
Tas & Dursonoglu (2005)	Turkey	1995-2004	-
Hassan et al. (2006)	7 European emerging stock markets	1988-2002	+(-)

3.3.3 Previous Researches on Chinese Stock Market Efficiency

Since the early 1990's, rapid financial development in China has attracted attention from both researchers and investors. As more data become more available, various researches have taken more interest in studying the financial characteristics of Chinese equity markets. Some of these studies have concentrated on the efficiency of the stock markets in China.

One of the earliest studies on Chinese stock markets can be contributed to Bailey (1994). Bailey (1994) examines the early evolutionary stage of both the Shanghai and Shenzhen stock markets return and risk. He used share prices of nine companies listed in Shanghai and Shenzhen exchanges and found that B-share display no or little correlation with international index returns. His results suggest that B-share can be considered good diversification investment for foreign investors and confirms the effectiveness of market segmentation in A-share and B-share markets.

Wu (1996) examine efficiency in both Chinese stock markets, on the early stage of development in Shanghai and Shenzhen stock exchanges. Using the serial correlation test on eight and twelve individual shares for the period from June 1992 to December 1993, he finds Chinese stock markets to be weak-form efficient. (Seddighi and Nian 2004)

Liu et al. (1997) examine daily closing prices on the Shanghai and Shenzhen stock exchanges using the ADF unit root and cointegration tests from the period May 21, 1992 to December 18, 1995. The ADF unit root test was used to test for randomness in each stock exchange share price index, and cointegration and causality tests are used to examine relationship between the two share price indexes. Their results suggest that the random walk for both the Shanghai and Shenzhen is accepted, indicating that each market is individually efficient. Results of the Engle-Granger two-stage and Johansen cointegration test find a stationary long-run relationship between two stock prices. In addition, the causal relationship between the Shanghai and Shenzhen stock indexes is found to be bidirectional. Consequently, both the cointegration and causality test results suggest that the both Chinese stock market are inefficient collectively.

Laurence et al. (1997) test for weak-form efficiency in the Shanghai and Shenzhen stock exchanges, and causality among these Chinese stock markets with each other and with the U.S. and Hong Kong stock markets. Their data include 1000 daily observations for Shanghai A-share, Shanghai B-share, Shenzhen A-share and Shenzhen B-share indices, Hong Kong stock exchange index and the Dow Jones industrial average for the U.S. from the period March 1993 to December 1996.

Laurence et al. (1997) show that the Ljung-Box test statistics indicate the presence of significant serial correlation in daily return series in all four Chinese stock shares, whereas the run test results show the presence of negative serial correlations in A-shares and positive serial correlations in B-shares for both stock exchanges. They also find that except for Shanghai B-share, the magnitude of serial correlation in the remaining three share decreases after the year 1994, indicating that the Chinese stock market are gradually moving to becoming efficient. Based on Granger causality test, Laurence et al. (1997) also observe a causal relationship between Shanghai B-share to other three Chinese stock markets and from Shanghai A-share and Shenzhen B-share back to Shanghai B-share. According to them, the causal relationship between B-share stock markets to the A-share stock markets imply that foreign markets exert a significant influence on the markets open only to Chinese nationals. In addition, they find a weak causal effect from Hong Kong to the four Chinese stock markets, and a strong causal effect from U.S stock market to all four Chinese stock markets and

Hong Kong stock market. Based on the results, they argue that Chinese stock markets are gradually become more integrated into the global economy.

Mookerjee and Yu (1999) test the efficiency of Chinese stock markets from the period December 19, 1990 to December 17, 1993 for the Shanghai stock exchange and from the April 3, 1991 to December 17, 1993 for the Shenzhen stock exchange. Their data include 759 daily closing prices for the Shanghai exchange and 727 daily closing prices for the Shenzhen exchange. Employing the serial correlation and the runs tests, they observe that there are significant inefficiencies present on both exchanges. Their study also tests for the presence of seasonal anomalies on both exchanges. They find significant weekend and holiday effects, but no January effects. Their results show that both exchanges are characterized by a statistically significant negative weekend and positive holiday effect. Particularly, their result suggests that Friday and holidays contain significant exploitable news for market participants. Mookerjee and Yu (1999) argue that their empirical findings also provide indirect support for the tax loss hypothesis and the small firm effects. According to them, the reasons for inefficiency in Chinese equity markets are derive from several factors. These reasons include the restricted supply of stocks; the fact that state and institutional entities hold a large percentage of stocks, and excessive volatility due to abrupt policy changes by the authorities. Moreover, they argue that inadequate infrastructure, both physically and legally, a shortage of expertise and geographical segmentation of markets could contribute to the inefficiency results as well.

Darrat and Zhong (2000) use the variance ratio test of Lo and MacKinlay (1988) and a model-comparison method to examine whether or not stock prices in both Chinese markets follow a random walk. They concentrate their investigation of the market behavior on daily data of the A-share closing index prices of the Shanghai exchange from December 20, 1991 to October 19, 1998 and the Shenzhen exchange from April 4, 1991 to October 19, 1998.

Their results from variance ratio and model-comparison tests indicate that A-share indices on both Chinese stock markets do not follow a random walk. Their results also show that prices of A-share indices exhibit positive autocorrelation, implying the potential for predictability. Darrat and Zhong (2000) further suggest that the inefficiency probably arise from thin trading and asymmetric information. They also claim that market imperfection such as ineffective legal structures and lack of transparency that prevents the smooth transfer of information, which typically characterized emerging markets, are also another explanation for inefficiency in Chinese stock markets.

Lee et al. (2001) investigate time-series features of stock returns and volatility in four of Chinese stock exchanges. They use daily returns of Shanghai A-share and B-share and Shenzhen A-share and B-share indices for the period 1990 to 1997. Applying the variance ratio test, they observe that Chinese stock market do not follow a random walk hypothesis. Their results indicate that stock returns are not independent and identically distributed in Chinese stock market. Moreover, they find the presence of negative serial correlation in return series indicating the possible mean reversion in returns. They suggest that mean reversion in Chinese stock returns is likely stem from thin trading.

Ma and Barnes (2001) examine the weak-form efficiency hypothesis for both the Shanghai and Shenzhen exchanges using serial correlation, runs and variance-ratio tests. They employ the daily, weekly and monthly returns of the six indices and four individual shares from December 1990 to April 1998 for the Shanghai market, and from April 1991 to April 1998 for the Shenzhen market. Indices tested in their study include the Shanghai Stock Exchange Index, Shanghai A-share and B-share, the Shenzhen Stock Exchange Index, and Shenzhen A-share and B-share. Individual share data consists of 375 Shanghai A-shares, 49 Shanghai B-shares, 348 Shenzhen A-shares and 51

Shenzhen B-shares. They observe that the daily returns on indices of the two markets are highly correlated, and the weekly returns and monthly returns on the indices are correlated as well, but not as significantly as the daily returns. They also find that the daily behavior of individual A-shares and B-shares of the Shanghai market and individual B-shares of the Shenzhen market do not follow a random walk. They observe that individual shares generally display more evidence of market efficiency than indices and there is more evidence of market efficiency for the Shenzhen than for the Shanghai market. Furthermore, the behavior of B-shares is found to exhibit more violations of the random walk hypothesis than of A-shares, indicating that B-shares' prices are more predictable than A-shares. They argue that thin trading is the most likely reason for inefficiency of B-shares. Ma and Barnes (2001) further claim that by Fama's (1965) standard Chinese stock markets can be argued to be weak-form efficient, but a comparison of their results with those of other countries suggest that Fama's (1965) benchmark is not strict enough. As the result, they conclude Chinese stock markets are not to be weakly efficient.

Seddighi and Nian (2004) study daily returns of the Shanghai Security Index and eight shares listed in the Shanghai stock exchange from the period January 2000 to December 2000. In their studies, eight companies are selected randomly from eight sectors, i.e. financial institutions, metal product, manufacturers, oil, gas and related services, information technology, automobile manufactures, agriculture, construction, and retailers. They employed three kinds of methods: the Lagrange Multiplier test is for autocorrelation and the Dickey-Fuller test is for unit root and ARCH test to examine whether the residuals contain some hidden, possibly non-linear structure, and fit a GARCH-M (1, 1) model to the first difference if the ARCH effect is found to be present in the share prices. They find that in the Shanghai Security Index, six of the companies' autocorrelation is not present, and all of the series have a unit root, which supports the random walk. However, they observe that autocorrelation is present in one of the company series, and two of the companies, there is no unit root in its series. The results of the ARCH test indicate that the ARCH effect exists in the series of three another companies. Therefore, they employ a GARCH-M (1, 1) model to fit for each of these three companies series. As the results there is no GARCH-M (1, 1) effects found in three of this series. They conclude that Chinese stock prices do not follow a random walk.

Lima and Tabak (2004) test the random walk hypothesis for the Shanghai and Shenzhen stock exchanges using daily returns from the period June 1992 to December 2000 for both A-share and B-share indices. Employing the single and multiple variance ratio tests, the random walk hypothesis is rejected for B-shares for the Shanghai and Shenzhen exchanges, but not for A-shares for both exchanges. They suggest that A-shares in Chinese stock exchanges are weak-form efficient. They suggest that liquidity and market capitalization may pay role in explaining results they find from tests of the random walk hypothesis. B-share markets have been illiquid and less active than A-share markets and its account for less than 5 percent of the total market capitalization.

Gao and Kling (2005) examine calendar effects in Chinese stock markets, particularly monthly and daily effects. Using individual stock returns on Shanghai and Shenzhen stock markets, they observe that Shanghai and Shenzhen stock markets exhibit daily and monthly calendar effects. They argue that China has two features related to calendar effects, which differ from other markets. One aspect is that the year ends in February; therefore, a January effect cannot be expected, and second is that tax-loss selling is not relevant since there are no taxes for capital gains. Their results show that the year-effect was strong in 1991, but disappeared later. As Chinese year-end is in February, they suggest that the highest returns can be achieved in March and April. They also find that the day-of-the-week effect follows a different pattern compared to other markets, as Mondays are considerably weak and Fridays show significantly positive average returns.

Overall, there is widespread but not unambiguous and contradictory evidence of departures from market efficiency in emerging markets and Chinese stock market as well. Based on these empirical findings, it can state that there is weak evidence for a random walk hypothesis or weak-form efficient in both Chinese stock exchanges. The above facts about the evidence on the Chinese stock market efficiency suggest the following general conclusions:

- Similar to other emerging stock markets, Chinese stock market exhibits information asymmetry, thin trading and weak institutional infrastructure, which all together could cause market inefficiency.
- China also differ along many dimensions from most emerging markets, such as segmentation of two share, and uncertainty in Chinese business and political environment which also could contribute to the inefficiency results.
- Contrary to another developed and emerging stock markets where generally market efficiency improve over time, evidence on Chinese stock market efficiency show that market is found to be weak-form efficient in early stages but not in recently.
- The different series or shares used and the different sample periods over which the data were measured provide conflicting evidence on weak form efficiency of the Chinese stock market.
- The evidence suggests that both Chinese stock markets are predictable, but inefficient with Shenzhen being a lesser degree.
- The behavior of B-shares displays more violations of the random walk hypothesis than A-shares in both Chinese stock markets.
- Similar to developed and emerging markets, Chinese stock markets also exhibit calendar effects, such as day of the week effects is found to be present in both Chinese markets.

4. DATA AND RESEARCH METHODOLOGY

4.1 Data and Hypotheses

To examine Chinese market efficiency, the data used in this study are daily price index data for Chinese stock exchanges in Shanghai and Shenzhen. The data of daily price indices are collected from the Datastream and the observation period ranges from February 21, 1992 to December 30, 2005. The empirical analysis of this study uses daily data of closing prices for the six indexes for the indicated sample periods, which are presented in following Table 3.

Table 3. Description of Data Sample

The data, obtained from Datastream, are collected on basis of the daily closing prices for weekdays (Mondays to Fridays) between the period February 1992 and December 2005. Shanghai A-share Index, Shanghai Composite Index, Shenzhen A-share Index and Shenzhen Composite Index are denominated in Chinese Yuan (CNY). Shanghai B-Share Index is denominated in US dollar and Shenzhen B-share Index in Hong Kong dollar. In August 2006, 1 US dollar is approximately 7.976 Chinese Yuans and 1 US dollar is about 7.9336 Hong Kong dollars.

Notations	Index	Sample period	Observations
SHSE-A	Shanghai A-Share Index	21/02/1992-30/12/2005	3616
SHSE-B	Shanghai B-Share Index	21/02/1992-30/12/2005	3616
SHSE-C	Shanghai Composite Index	21/02/1992-30/12/2005	3616
SZSE-A	Shenzhen A-Share Index	05/10/1992-30/12/2005	3455
SZSE-B	Shenzhen B-Share Index	05/10/1992-30/12/2005	3455
SZSE-C	Shenzhen Composite Index	21/02/1992-30/12/2005	3616

These three of the Shanghai and three of the Shenzhen stock market indices are chosen because they are the most authoritative statistical indices used by domestic and overseas investors in measuring the performance of Chinese securities market. Shanghai A-share, Shanghai B-share and Shanghai Composite indices are a weighted average of the stock prices listed in the Shanghai stock exchange with the value as the weight. Shenzhen A-share, Shenzhen B-share and Shenzhen Composite indices are also a weighted average of the stock prices listed in the Shenzhen stock exchange with the value as the weight.[26]

The span of period in sampling of data was restricted due to the availability of data. We choose the daily closing prices of Shanghai A, Shanghai B, Shanghai Composite and Shenzhen Composite indices from February 21, 1992 to the end of 2005 as the whole sample, while Shenzhen A and Shenzhen B indices from October 5, 1992 to the end of 2005 as the whole sample. This choice follows from two considerations. First, before 1992 when China Securities Regulatory Commission was founded, there was no government commission to supervise Shanghai and Shenzhen stock exchanges consistently, and both exchanges were operated separately. Second, the choice of the sample period is based on the high volatility of the markets before 1992.

Since the Chinese stock market has experienced major structural changes with the potential for affecting market efficiency, we divide our chosen sample period into three following sub-periods of differing market environments:

1) February 21, 1992 (October 5, 1992) - December 29, 1995 periods during its early stage of Chinese stock market development;

2) January 1, 1996 - December 30, 2000 periods during which the Chinese stock market grew significantly in size and number, and which is know as the Chinese stock market boom;

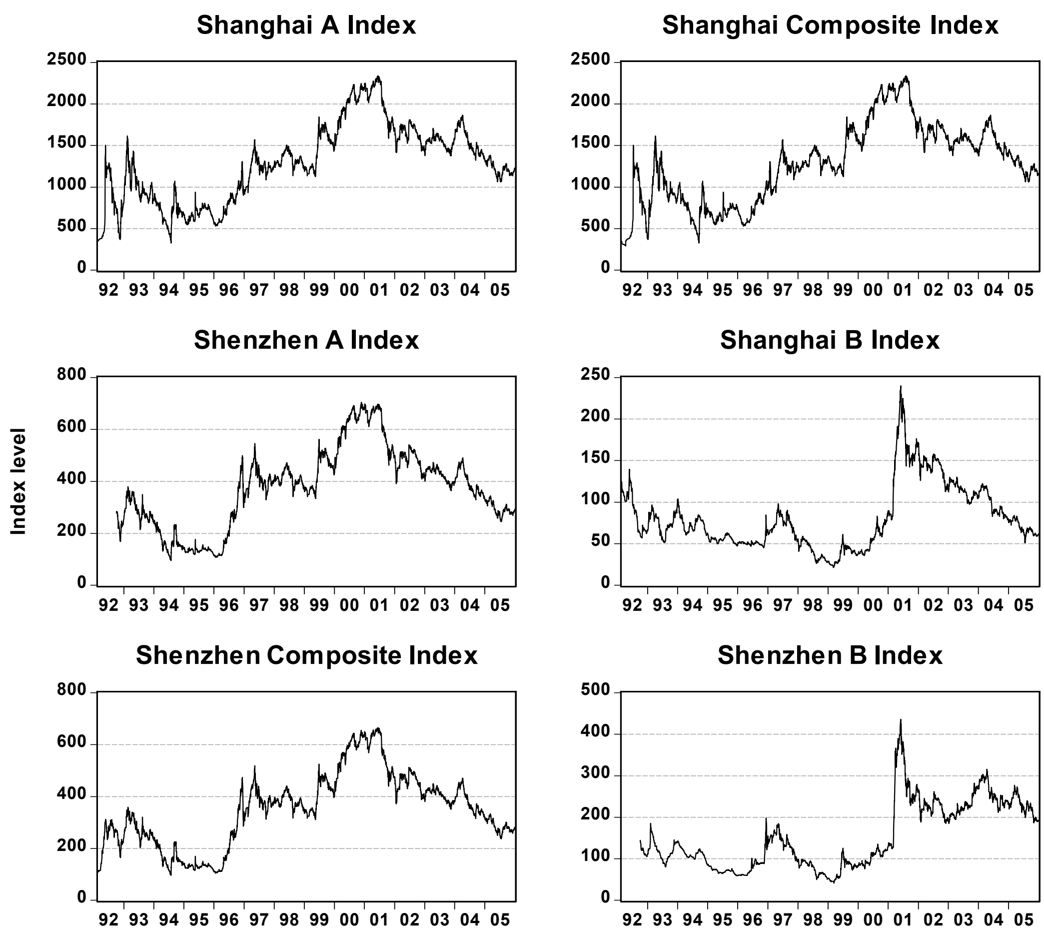
3) January 2, 2001 - December 30, 2005 periods after market crash.

[26] See Appendix 1 and 2 for more detailed information about Chinese stock market indices' base value, launch and base day.

We believe that the sample of this study provides us with a greater variety of information, which should reflect the dramatic changes that have taken place in Chinese securities sector in the past decade. Figure 3 shows the index price movements of the Shanghai and Shenzhen stock markets for the full sample period. Examining visually the plots of the variables can provide general ideas how these indices evolve over time.

Figure 3. Time Series Plots of Chinese Stock Market Indices

The graph shows the time series plots of the Shanghai and Shenzhen markets indices. Daily closing prices of each index are used from the full sample period February 1992 to December 2005. Shanghai A-share Index, Shanghai Composite Index, Shenzhen A-share Index and Shenzhen Composite Index are denominated in Chinese Yuan (CNY). Shanghai B-Share Index is denominated in US dollar and Shenzhen B-share Index in Hong Kong dollar.



Both Chinese stock markets have experienced some large ups and downs during the sample period 1992 to 2005. As Figure 3 shows, the price movements of all Shanghai and Shenzhen indices appear to be nearly identical. Certain degree of similarity exists between Shanghai A-share, Shanghai Composite and Shenzhen A-share and Shenzhen Composite indices, whereas movements of Shanghai B-share and Shenzhen B-share indices seem to behave nearly same. Shanghai and Shenzhen both markets suffered two large downturns between end of 1994 and end of 1996, and early 1998 and mid-2000. Similarly, all indices reached the peak in July 2001. The graph also reveals an upward trend for each of the Shanghai and the Shenzhen indices, but not for Shanghai B-share index and Shenzhen B-share index, from 1996 to 2000, and a subsequent downward trend for all indices after mid-2001.

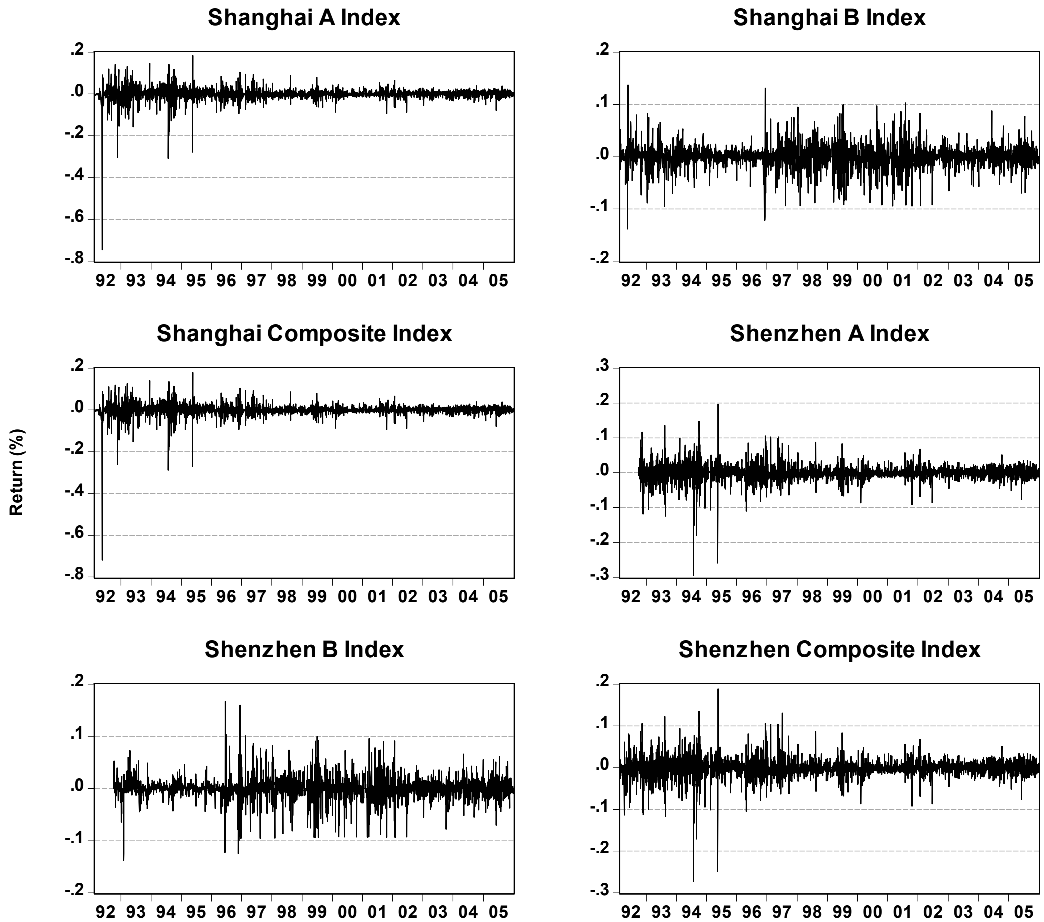
Figure 4 shows the plots of the daily returns of each of the Shanghai and the Shenzhen indices. All index series returns are calculated using the continuously compounded formula:

$$R_t = \ln\left(\frac{p_t}{p_{t-1}}\right) \tag{4}$$

where p_t and p_{t-1} represent the closing prices of an index at time t and t-1, respectively and ln is natural logarithm. (Brooks 2004, 7)

Figure 4. Time Series Plots of Daily Returns of Chinese Stock Market Indices

The graph shows the plots of continuously compounded return series of the Shanghai and Shenzhen markets for the full sample period February 1992 to December 2005.



Observed from the plots, returns of all two markets indices seem to fluctuate around zero and periods where returns seem to tranquil alongside periods with large increases and decreases. Returns of Shanghai A-share and Shanghai Composite indices have higher variations moving between a range of +20% to -20%, compared with returns of Shenzhen A-share and Shenzhen Composite indices that move between a smaller range between +10% to -10%, except for a few outliers. The variations in returns seem to decrease over time for returns of all indices, except for Shanghai B-share index and Shenzhen B-share index. Shanghai B-share index and Shenzhen B-share index seem to have a prominent periods in which variance is relatively high.

After considered all the arguments above, the testable hypothesis should be defined. The main objective of this study is to examine whether the Chinese stock market follows a random walk or is weak form efficient. Accordingly, the hypothesis of the study is:

$H_{0:}$ The Chinese stock market follows a random walk/ is a weak-form efficient

H_1: The Chinese stock market does not follow the random walk

Our second purpose is to examine the day-of-the-week effect on each Chinese stock market. The day of the week effect is tested using the ordinary least squares (OLS) regression, which is explained in later section. Accordingly, second hypothesis to be tested is:

$H_{0:}$ There is no difference in returns between the days of the week

H_1: There is difference in returns between the days of the week

The null hypothesis of a random walk model is tested using various statistical tests including serial correlation, runs test, variance ratio and unit root tests. Serial correlation, variance ratio and runs tests are performed on the three sub-samples and the full sample. Tests for unit root and day-of-the-week effect are performed only on the full sample.

4.2 Random Walk Hypothesis Formulation

The starting point of our analysis is the hypothesis of an efficient market, hence, randomness of returns can be assumed. Accordingly, we state that market returns follow a random walk that is that the logarithmic market indices follow a random walk. Theory of random walk in stock prices involves two hypotheses: the successive price changes are independent and the price changes conform to some probability distribution (Fama 1965). The simplest and the strongest version of the random walk hypothesis are based on independently and identically distributed (IID) increments where the dynamics of stock prices are given by the following equation:

$$P_t = P_{t-1} + \mu + \varepsilon_t, \quad \varepsilon_t \sim IID\, N(0, \sigma^2) \tag{5}$$

where P_t is price of the financial asset observed at time ***t*****,** μ is the expected price change or a random walk with drift, and IID (0, σ^2) denotes that ε_t (error term) is independently and identically distributed with mean 0 and variance σ^2. The independence of the increments $\{\varepsilon_t\}$ implies that the random walk is not only a fair game, but also in a much stronger sense than the martingale. Independence implies not only that the increments are uncorrelated, but any nonlinear functions of the increments are also uncorrelated. The distributional assumption suffers from violations of limited liability. That is, if conditional distributional of P_t is normal, then there will always be a positive probability that $P_t < 0$. In order to avoid violating limited liability, the study uses natural logarithm of prices, which follows a random walk with normally distributed increments. (Campbell et al. 1997, 31-33)

Campbell, Lo and MacKinlay (1997) represent a revised and extended theory of the random walks. Their proposition provides a number of complementary testing procedures for random walks. They summarize the major properties of martingales and random walks and incorporate them into three random walk hypotheses. Specifically, they introduced following formula that may constructed as an orthogonality conditions where all versions of the random walk and martingales hypotheses are captured by:

$$Cov[f(r_t), g(r_{t+k})] = 0 \tag{6}$$

where $f(r_t)$ and $g(r_{t+k})$ are two arbitrary functions, r_t and r_{t+k} are asset's returns at t and $t+k$, for all t and for $k \neq 0$. If (6) holds for all functions $f(r_t)$ and $g(r_{t+k})$, this implies that if returns are mutually independent, it corresponds to the Random Walk 1 and Random Walk 2 models. Random Walk 1 (RW1) is simplest version of random walk, i.e., formula of (5), with independent identically distributed increments. The Random Walk 2 (RW2) contains RW1 as a special case, but it is weaker version of RW1, with independent, but not identically distributed increments. RW2 allows more general price process, such as unconditional heteroskedasticity in the increments. Finally, the weakest version of the random walk hypothesis is the Random Walk 3 (RW3), which contains RW1 and RW2 as special cases. If $f(r_t)$ and $g(r_{t+k})$ are arbitrary linear functions, then (6) implies that returns are serially correlated corresponding to the RW3, random hypothesis with independent, but uncorrelated increments. (Campbell et al. 1997, 28)

4.3 Statistical Tests for Market Efficiency

In this study, we use four statistical methods, namely a serial correlation test, a runs test, a variance ratio test and an Augmented Dickey-Fuller unit root test to examine market efficiency. In addition, the ordinary least squares (OLS) regression is used to test the day-of-the-week effect. The data is subjected to a serial correlation test, a non-parametric runs test and a variance ratio tests to determine the level of dependency among successive returns of Chinese stock market. The non-parametric run test is one of the most well known earlier tests of the random walk hypothesis, which are based on the test of IID assumptions of the random walk increments, while the serial correlation tests are based on the test of the weakest version of the random walk, RW3. The variance ratio tests was developed by Lo and MacKinlay (1988) have shown that the variance ratio tests is not only more powerful compare to the previous two tests, but it is also more reliable test of the random walk hypothesis, which allows testing all three versions of the random walk hypothesis. Test for unit roots are also used to determine if the series is difference or trend non-stationary as it is a necessary condition for random walk. These statistical tests are discussed more closely in each following sub-sections. A model to test for day of the week effect is introduced in the end.

4.3.1 Serial Correlation Test

As noticed in the literature, a serial correlation test is the most commonly use as the first tool for randomness. Under the weakest version of the random walk (RW3), the increments or first-differences of the level of the random walk is uncorrelated at all leads and lags. Serial correlation test measures the correlation coefficient between a series of returns and lagged returns in the same series, whether the correlation coefficients are significantly different from zero. The autocorrelation in returns of Chinese stock markets are tested whether returns can be characterized by serial dependence.

The autocorrelation coefficient is a natural time series extension of the correlation coefficient between two random variables *x* and *y* (Campbell et al. 1997, 44). Given a covariance-stationary time series r_t and the k^{th} order autocorrelation coefficient denoted as $\rho(k)$, the model of serial correlation coefficient is:

$$\rho(k) = \frac{Cov(r_t, r_{t-k})}{\sqrt{Var(r_t)}\sqrt{Var(r_{t-k})}} = \frac{Cov(r_{t,} r_{t-k})}{Var(r_t)} \qquad (7a)$$

where $\rho(k)$ is the autocorrelation coefficient of time series r_t ; r_t is the return on a security at time *t, k* is the lag of the period. $Cov(r_t, r_{t-k})$ denotes the covariance between the return of an index over time period (*t*-1, *t*) and its lagged return *t*-*k* periods earlier, and $Var(r_t)$ denotes the variance on the return of a security over time period (t-1, t). Hence, serial autocorrelation can be examined by estimating the sample autocorrelation coefficients:

$$\rho_k = \frac{\frac{1}{T-K}\sum_{t=k+1}^{T}(y_t - \bar{y})(y_{t-k} - \bar{y})}{\frac{1}{T}\sum_{t=1}^{T}(y - \bar{y})^2} \quad (7b)$$

where $\bar{y}$ is the sample mean of series y and k is the time lag. The zero lag coefficients ρ_0 are always equal to one by definition, and higher lag coefficient generally damp towards small values with increasing lag. Nonzero r_0 implies that the series is first order serially correlated. (Enders 2004, 67) In large samples, if the autocorrelation is zero, then the sample of autocorrelations are approximately normally distributed with mean 0 and variance 1/T. Then this sample autocorrelation can be used to conduct significance tests for the autocorrelation coefficients in a given confidence interval for an estimated autocorrelation coefficient to determine whether it is significantly different from zero. A 95% confidence interval is ±1.96$\times 1\sqrt{T}$. Thus, if the sample autocorrelation coefficient (ρ_k) falls outside this region for a given value of k, then the null hypothesis that value of coefficient at that lag k is zero is rejected. (Brooks 2004, 233)

The Q-statistic is also used to test whether the all autocorrelations is significantly different from zero. Box and Pierce (1970) formed the Q-statistic as follows:

$$Q_k = n\sum_{k-1}^{m}\rho^2(k) \quad (8a)$$

Under null hypothesis all values of $\rho(k)$= 0, Q_k is asymptotically Chi-Squared (χ^2) distributed with *m* degrees of freedom, *m* is the maximum lag length and *n* is the sample size. The perception behind the use of the statistic is that high sample autocorrelations lead to large values of *Q.* If the calculated value of *Q* exceeds the appropriate value in a χ^2 table, we can reject the null hypothesis of no significant autocorrelation at the appropriate significance level. Rejecting the null hypothesis means accepting an alternative that at least one autocorrelation is not zero. (Enders 2004, 68) Under the same hypothesis, Ljung and Box (1978) provide the finite-sample correction that yields a better fit to the χ^2 distribution for small sample sizes:

$$Q_{LB} = n(n+2)\sum_{k=1}^{m}\frac{\rho^2(k)}{(n-k)}, \quad \sim \chi_m^2 \tag{8b}$$

where $\rho(k)$ is the estimated autocorrelation coefficients, *k* is a given lag; *k* takes the values of 1 to 12 lags and *n* is the sample size. If the calculated value of Q_{LB} exceeds the critical value of χ^2 with *m* degrees of freedom, then at least one value of $\rho(k)$ is statistically different from zero at the specified significance level.[27]

4.3.2 Runs Test

A runs test is another common approach to test for statistical independencies or RW1, but unlike autocorrelation coefficient, it does not require returns to be normally distributed. The runs test is a non-parametric test that is designed to examine whether successive price changes are independent. The test is based on the premise that if a series of a data is random, the observed number of runs in the series should be close to the expected number of runs.

[27] For further details see, e.g., Enders (2004, 68)

A run can be defined as a sequence of consecutive price changes with the same sign. The non-parametric runs test is applicable here as a test of randomness for the sequence of return. Accordingly, it tests whether returns in Chinese stock market are predictable.

The null hypothesis of randomness is tested by observing the number of runs or the sequence of successive price changes with the same sign, positive, zero or negative. (Campbell et al. 1997, 38) To assign equal weight to each change and to identify direction of consecutive changes, each change in return is classified according to its position with respect to the mean return. Hereby it is a positive change when return is greater than the mean, a negative change when the return is less than the mean and zero when the return equals to the mean. (Worthington and Higgs 2004)

To perform the runs test, the sampling distribution of total number runs in a sample is required. It has been shown that the distribution of the number of runs converges to a normal distribution asymptotically when properly normalized. (Campbell et al. 1997, 39) The runs can be carried out by comparing the actual runs (*R*) to the expected number of runs (*m*) using following equation:

$$m = \frac{N(N+1) - \sum_{i=1}^{3} n_i^2}{N} \tag{9a}$$

where *N* denotes the number of observations, *i* is the signs of plus, minus, and no change, n_i is total numbers of changes of each category of signs. For a larger number of observations (*N* > 30), the expected number of runs *m* is approximately normally distributed with a standard deviation σ_m of runs as specified in the following formula:

$$\sigma_m = \left[\frac{\sum_{i=1}^{3} n_i^2 \left[\sum_{i=1}^{3} n_i^2 + N(N+1) \right] - 2N \sum_{i=1}^{3} n_i^3 - N^3}{N^2(N-1)} \right]^{\frac{1}{2}} \qquad (9b)$$

Then the standard normal *Z*-statistic used to conduct a run test is given by:

$$Z = \frac{R - m \pm \left(\frac{1}{2}\right)}{\sigma_m}, \qquad Z \sim N(0,1) \qquad (9c)$$

where *R* is the actual number of runs, and ½ denotes the correction factor for continuity adjustment (Ma and Barnes 2001), in which the sign continuity adjustment is positive if $R \leq m$, and negative if $R \geq m$. A negative *Z* value indicates a positive serial correlation, whereas a positive *Z* value indicates a negative serial correlation. The positive serial correlation implies that there is a positive dependence of stock prices, therefore indicating a violation of random walks. Since the distribution *Z* is *N*(0,1), the critical value of *Z* at the five percent significance level is ±1.96.

4.3.3 Variance Ratio Test

After both tests for serial independence in the series have been introduced, another important property of all random hypotheses has to be considered. That is linearity in random walk series increments. We use the variance ratio test proposed by Lo and MacKinlay (1988) to examine whether the increments of all three random walk hypotheses are linear function of the time interval. The variance ratio test is used to test for a random walk in returns, i.e., that returns are independently and identically distributed with a constant mean and finite variance that is a linear function of the holding period. According to Campbell, Lo and MacKinlay (1997, 48), this linearity is more difficult to indicate in the case of RW2 and RW3 since the variances of increments may vary through time. The RW1 can be simply investigated by comparing the variance of $r_t + r_{t-1}$ to twice the variance r_t. [28] The variance ratio test of Lo and MacKinlay (1988) examine the uncorrelated residuals in series, under assumptions of both homoscedastic and heteroskedastic random walks.

The variance ratio test exploits the fact that the variance of the increments in a random walk is linear in the sampling interval such that if the return series follows a random walk model, the variance of its *q*-differences would be *q* times the variance of its first differences. More generally, if time series follows a random walk process, the variance of q period returns should be q times as large as the one-period returns:

$$VR(q) = \frac{Var[r_t(q)]}{Var[r_t]} = q \qquad (10a)$$

Then, the variance ratio for a general *q* can be rewritten as *VR*(*q*) and satisfies the following relation:

$$VR(q) = \frac{Var[r_t(q)]}{q \times Var[r_t]} = 1 + 2\sum_{k=1}^{q-1}\left(1 - \frac{k}{q}\right)\hat{\rho}(k) \qquad (10b)$$

where $r_t(k) = r_t + r_{t-1} + \ldots + r_{t-k+1}$ and $\hat{\rho}(k)$ is the k^{th} order autocorrelation coefficient of r_t. This results into *VR*(*q*) is a particular linear combination of the first *k*-1 autocorrelation coefficients of r_t with linearly declining weights. Under the RW1, the variance ratio should equal to one [*VR*(*q*)=1] and in this case $\rho(k)=0$ for all $k \geq 1$. Likewise, under RW2 and RW3, *VR*(*q*)=1 must still equal to one as long as the variances of r_t. are finite.

---

[28] Under RW1 for log prices where continuously compounded returns $r_t = \ln P_t + \ln P_{t-1}$ are IID (Campbell et al. 1997, 48)

Lo and MacKinlay (1988) derive asymptotic standard normal test statistic for their variance ratio. As a result, the null hypothesis of no autocorrelation coefficient can be tested by computing the standardized statistic. (Campbell et al. 1997, 50) Under the null hypothesis of homoscedastic, the standard normal test statistic *Z*(q) is defined as

$$Z(q) = \frac{VR(q) - 1}{\Phi(q)^{1/2}} \quad \sim N(0,1), \tag{11a}$$

where

$$\Phi(q) = \frac{2(2q-1)(q-1)}{3q(nq)} \tag{11b}$$

here nq is the number of observations and $\Phi(q)$ is the asymptotic variance of the variance ratio under the assumption of homoscedasticity. The rejection of random walk under homoscedasticity may result from either heteroscedasticity and/or autocorrelation existence in series (Worthington and Higgs 2004). It is observed by the financial economists that volatilities change over, a rejection of the random walk hypothesis because of heteroscedasticity. As long as returns are uncorrelated, even in the presence of heteroscedasticity the variance ratio still approach unity as the number of observations increases without bound, for the variance of the sum of uncorrelated increments still equal the sum of the variances (Campbell et al. 1997, 53). To allow general forms of heteroscedasticity, Lo and MacKinlay (1988) recommended heteroscedasticity-consistent method. The heteroscedasticity-consistent standard normal test statistic, *Z**(q) is then defined as

$$Z^*(q) = \frac{VR(q) - 1}{\Phi^*(q)^{1/2}} \quad \sim N(0,1), \tag{12a}$$

where the standard error term is

$$\Phi^*(q) = 4\sum_{k=1}^{q-1}\left[1-\frac{k}{q}\right]^2 \hat{\delta}(k) \qquad (12b)$$

and

$$\hat{\delta}(k) = \frac{nq \sum_{j=k+1}^{nq}\left(p_j - p_{j-1} - \hat{\mu}\right)^2 \left(p_{j-k} - p_{j-k-1} - \hat{\mu}\right)^2}{\left[\sum_{j=1}^{nq}\left(p_j - p_{j-1} - \hat{\mu}\right)^2\right]^2}, \qquad (12c)$$

where $\hat{\delta}(k)$ is the heteroscedasticity-consistent estimator, p_j is the price of the security at time *t* and $\hat{\mu}$ is the average return. Under the null hypothesis, the value of the variance ratio is one. If the heteroskedastic random walk is rejected, then there is evidence of autocorrelation presences in series (Worthington and Higgs 2004). Furthermore, if calculated variance ratio is less than one then it would imply negative serial correlation, whereas a variance ratio greater than one would indicate positive serial correlation (Darrat and Zhong 2000). We conclude that returns are predictable if variance ratio is greater than one. In order to compare with results Campbell et al. (1997, 48-55), and Ma and Barnes (2001), variance ratio tests are conducted for lags of 2, 4, 8, 12 and 16 days.[29]

4.3.4 Unit Root Test

The subsequent research about the market efficiency has used a new methodology to test the random walk nature of stock prices that is known by

[29] Appendix 5 summarizes the values of autocorrelation coefficient, which are used to calculate variance ratios.

unit root test.[30] This methodology was developed by Dickey and Fuller (1981) is used to examine the stationarity of the time series. The unit root test is designed to discover whether the series is difference-stationary (the null hypothesis) or trend-stationary (the alternative hypothesis) (Campbell et al. 1997, 65). A series with unit root is said to be non-stationary indicating non-random walk. The most commonly used test to examine the existence of a unit root is the Dickey-Fuller test. This unit root test provides evidence on whether the stock prices in Chinese stock market follow a random walk. Therefore, it is also a test of the weak-form market efficiency.

The standard Dickey-Fuller (DF) test is appropriate for a series generated by an autoregressive process of order one, AR(1). If, however, the series follows an AR(*p*) process where *p*>1, the error term in the standard DF test will be autocorrelated. Autocorrelated will invalidate the use of the DF test distribution, which is based on the assumption that the error term is white noise. The Augmented Dickey-Fuller (ADF) test includes additional lagged difference terms to account for this problem. (Eviews 2004; Dickey and Fuller 1981) The ADF unit root test is based on the following regression:

$$\Delta P_t = \gamma P_{t-1} + \sum_{i=1}^{q} \rho_i \Delta P_{t-i} + \varepsilon_t \qquad (13a)$$

$$\Delta P_t = \mu + \gamma P_{t-1} + \sum_{i=1}^{q} \rho_i \Delta P_{t-i} + \varepsilon_t \qquad (13b)$$

$$\Delta P_t = \mu + \alpha_1 t + \gamma P_{t-1} + \sum_{i=1}^{q} \rho_i \Delta P_{t-i} + \varepsilon_t \qquad (13c)$$

[30] A random walk is a special case of a unit root process.

where Δ represents first differences and P_t is the log of the price index, μ is the constant, γ and ρ are coefficients to be estimated, q is the number of lagged terms, t is the trend, a_1 is the estimated coefficient for the trend, and the error term ε_t is assumed to be white noise. Then the null hypothesis to be tested is:

H_0: ρ = 0 (Non-stationary or unit root)

H_1: ρ < 0 (Stationary or no unit root)

The first equation (13a) is a pure random walk model without constant and time trend, the second with constant without time trend, and third includes both constant and time trend. Accordingly, equation (13b) tests for the null hypothesis of a random walk against a stationary alternative, while equation (13c) tests for the same null against a trend stationary alternative.

To test the significance of the estimated γ coefficients, the Augmented Dickey-Fuller unit root test is computed the tau statistic (τ) for each estimated coefficient, in the same way as a student's *t*-statistic is calculated. However, the estimated τ values do not follow the same distribution as student's *t*. The statistical significance of the estimated τ values must be assessed by comparing them with critical values derived for the τ distribution tabulated in Dickey and Fuller (1981). If the estimated τ value is less than the critical value in absolute terms, then the null hypothesis of the existence of unit root cannot be rejected. It is important to notice that the appropriate critical values depend on sample size, since as in most of hypothesis tests, for any given level of significance the critical values of the t-statistic decrease as sample size increases. (Enders 2004, 182; Eviews 2004) MacKinnon (1991) estimates the calculation of Dickey-Fuller critical values for any sample sizes is hereby used here (Eviews 2004).

4.3.5 Test for Day-of-the-Week Effect

The most serious violations of the random walk hypothesis on developed markets have been associated with calendar turning points such as weekends, turn of year and holidays. The most common observed calendar effect in daily data is a day of the week effect. Given that a weekend effect has been identified by a number of researchers, and as a further weak form efficiency of the Chinese stock market, we also examine the day-of-the-week effect. Similar to previous studies, the following regression is run for the whole period to test whether there is any statistical significant difference among index returns on different days of the week:

$$R_t = b_1 D_{1t} + b_2 D_{2t} + b_3 D_{3t} + b_4 D_{4t} + b_5 D_{5t} + \varepsilon_t \qquad (14a)$$

where R_t is the return at time t, D_{1t} is a dummy variable with a value of Monday and 0 otherwise; D_{2t} =1 if the day is a Tuesday and 0 otherwise; and so on. The ordinary least squares (OLS) coefficients b_1 to b_5 are the mean returns for Monday through Friday, respectively and ε_t denotes the random disturbance term. The hypothesis to be tested is:

$$H_0 : b_1 = b_2 = b_3 = b_4 = b_5 \qquad (14b)$$

If there is no day-of-the-week effect in mean returns, the coefficients are not significantly different from zero. F-statistic is used to test this hypothesis, that coefficients b_1 through b_5 would be identical. Rejection of the hypothesis implies that at least one of the five daily rates of return is not equal to the others. The day-of-the-week effect is also examined by checking significance of the coefficients b_1 through b_5. The existence of day-of-the-week effect will be confirmed when coefficient of at least one dummy variable is statistically significant. (Brooks 2004, 538-539) The presence of day of the week in returns will indicate that stock returns in China are not entirely random.

5. EMPIRICAL RESULTS

5.1 Descriptive Statistics

A summary of descriptive statistics for all stock returns series in both Shanghai and Shenzhen stock markets for the entire sample period 1992 to 2005 are presented in Table 4a and 4b. From the Table 4a, it can be seen that except Shanghai B-share index (SHSE-B), all indexes have negative mean returns. SHSE-B has the highest mean returns of 0.0193, while Shanghai A-share index (SHSE-A) has the lowest mean return of -0.0345. The lowest minimum returns are in Shanghai A-share index and the highest maximum returns are in Shenzhen A-share (SZSE-A). The standard deviations of returns range are from 0.0214 (SHSE-B) to 0.0284 (SHSE-A). On this basis, the returns of SHSE-B and SZSE-B are the least volatile, with SHSE-A and SHSE-C being the most volatile. Overall returns of Shenzhen indices are less volatile compare with returns of Shanghai indices and Shanghai market has higher returns than Shenzhen market.

Table 4a. Descriptive Statistics for the Daily Index Returns

The table presents descriptive statistics for continuously compounded daily Shanghai and Shenzhen markets stock returns. These include mean, maximum, minimum value and standard deviation. N denotes the number of observations. The mean, maximum and minimum values are multiplied by 10^2. Estimates are given for the full sample period 1992-2005.

Time series	N	Mean	Maximum	Minimum	Standard deviation
Shanghai					
A Index	3616	-0.0345	18.427	-74.517	0.0284
B Index	3616	0.0193	13.716	-13.821	0.0214
Composite	3616	-0.0324	17.905	-71.915	0.0273
Shenzhen					
A Index	3455	-0.0006	19.632	-29.577	0.0230
B Index	3455	-0.0088	16.699	13.798	0.0216
Composite	3616	-0.0248	18.883	-27.215	0.0226

Table 4b reports skewness, kurtosis and Jarque-Bera statistics and its *p*-values for each time series. In general, values for skewness zero and kurtosis value three represents that observed distribution is normally distributed.

Table 4b. Descriptive Statistics for the Daily Index Returns

The table reports the tests of normality for daily stock returns on Shanghai and Shenzhen markets. Skewness, Kurtosis and Jarque-Bera are calculated for the full sample period 1992-2005.

Time series	Skewness	Kurtosis	Jarque-Bera	Jarque-Bera *p*-value
Shanghai				
A Index	-6.1518	147.755	3179874.00	<0.001
B Index	-0.3939	8.921	5375.15	<0.001
Composite	-6.1162	148.794	3225116.00	<0.001
Shenzhen				
A Index	-1.0562	22.593	55906.10	<0.001
B Index	-0.3761	11.058	9428.08	<0.001
Composite	-0.8789	19.236	40182.81	<0.001

As can be seen in Table 4b the skewness and kurtosis values indicate that returns of all indexes are not normally distributed. Returns of all indexes are negatively skewed or skewed to the left, indicating greater probability of large deceases in returns than rises. SHSE-A has the highest negative value of skewness, while SZSE-B has the lowest. The evidence of negative skewness for all return series in both Shanghai and Shenzhen stock markets are similar to findings of Huang (1995) in nine Asian stock markets, Gilmore and McManus (2003) in three European emerging stock markets, and Worthington and Higgs (2004) in sixteen developed markets and four European emerging stock markets. Their negative skewness coefficients are, however, lesser. However, our evidence of negative skewness values differ from previous findings of Laurence et al. (1997), Mookerjee and Yu (1999), Lee et al. (2001) in both Chinese stock markets. Their data cover only early stage of the Chinese stock market. This finding may suggest that returns were likely increased than falls in early stage of the Chinese stock markets, but this has changed over the time.

The kurtosis or degree of excess, in all index returns is also large, ranging from 8.921 for SHSE-B to 148.794 for SHSE-C, thereby indicating leptokurtic distributions. High positive value of kurtosis signifies that the distributions of these variables are centered. Particularly, the distributions of SHSE-A and SHSE-C are strongly centered. The evidence of high kurtosis value is also consistent with the previous findings in emerging markets, see e.g., Huang (1995), Mobarek and Keasey (2002), Gilmore and McManus (2003), Worthington and Higgs (2004), and Hassan et al. (2006). Our findings do not differ from previous studies on Chinese stock markets either. The calculated Jarque-Bera statistics and corresponding *p*-values in Table 4b are used to test the null hypotheses that the daily distribution of Shanghai and Shenzhen markets returns is normally distributed. All *p*-values are smaller than the .01 level of significance suggesting the null hypothesis can be rejected. Therefore, none of these return series is then well approximated by the normal distribution.

5.2 Unit Root

Since a unit root is a necessary condition for a random walk, the Augmented Dickey-Fuller test is used to test the null hypothesis of a unit root. The results of Augmented Dickey-Fuller for a unit root for Chinese stock price indices are presented in Table 5. Augmented Dickey-Fuller unit root test was performed including intercept, intercept and time trend, or without intercept and time trend for the whole sample period 1992-2005.

Table 5. Results of the Augmented Dickey-Fuller Unit Root Test for Stock Index Prices

This table reports the results of the Augmented Dickey-Fuller unit root test for Shanghai and Shenzhen index prices for the full sample period 1992-2005. The optimal lag length for the ADF is selected with the Schwartz Info Criterion and maximum lag is set to 12. The τ statistic applies to regression (12.1) without constant and time trend, for regression (12.2) with constant but without time trend, while with constant and time trend in regression (12.3) are tested in levels and first differences.

	Level		
Shanghai	**None**	**Intercept**	**Intercept and Trend**
A share Index	-0.3349	-2.3843	-2.2691
B share Index	-1.2308	-1.8732	-2.1040
Composite Index	-0.3215	-2.3564	-2.2346
	First difference		
Shanghai	**None**	**Intercept**	**Intercept and Trend**
A share Index	-58.2482***	-58.2442***	-58.2522***
B share Index	-53.6506***	-53.6469***	-53.6412***
Composite Index	-58.1835***	-58.1793***	-58.1873***
	Level		
Shenzhen	**None**	**Intercept**	**Intercept and Trend**
A share Index	-0.5062	-1.3959	-1.2022
B share Index	-0.6581	-1.8117	-2.6502
Composite Index	-0.3256	-1.8731	-1.3846
	First difference		
Shenzhen	**None**	**Intercept**	**Intercept and Trend**
A share Index	-58.3338***	-58.3254***	-58.3258***
B share Index	-24.4197***	-24.4171***	-24.4140***
Composite Index	-26.6004***	-26.5995***	-26.6251***

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

Results from the Table 5 shows that the index series in both markets are non-stationary in levels, but become stationary in first-differences. The ADF test fails to reject the null hypothesis for all index levels, thereby implying that all of price indices examined are non-stationary. However, after taking first differences on price indices, the null hypothesis of a unit root is rejected at the 1% level of significance. This indicates that all index levels are stationary and are integrated of order one. The result therefore indicates that there exists some evidence of random walks in all of the six index series. However, the existence of random walk components in stock price does not necessarily imply that stock returns are unpredictable. If stock returns are characterized by a white noise process, the corresponding price indices are said to follow a random walk. In that case, the stock returns are unpredictable.

Based solely on unit root tests we may not conclude that Shanghai and Shenzhen stock markets are weak-form efficient, since the ADF unit root test only examined the existence of stochastic trend components, but does not detect the predictability in returns. Whether Shanghai and Shenzhen stock prices violate the random walk hypothesis is needed to examine further.

5.3 Serial Correlation

The results of the first twelve sample autocorrelation coefficients and Ljung-Box statistics for the first four orders and the sixth and twelfth-order autocorrelation for each return series of the Shanghai and Shenzhen markets for the full sample period 1992-2005 are presented in Table 6.

The autocorrelation coefficient at lag one is lowest for Shenzhen A-share index (0.013) and highest for the Shanghai B-share (0.162). Except Shenzhen A-share index, significant positive autocorrelation is detected at a lag of one period for return series in both Shanghai and Shenzhen stock markets. For higher-order autocorrelation, lag 12, all return series also show a consistent pattern of positive autocorrelation. Positive autocorrelation indicates predictability of returns in short horizon, which is the general evidence against market efficiency. On the other hand, negative autocorrelation, indicating mean reversion in returns, with mean reversion being higher in A-share and Composite indices in both markets. Shanghai A-share and Composite indices in both markets appear the significant negative autocorrelation at lag 6, 7, 8, 10 and 11. Shanghai B-share index also show significant negative autocorrelation at lag 6. Overall, for returns on indices of both markets, except for a very few lags the autocorrelation coefficients for most lags are non-zero at the 1%, 5% and 10% significance levels.

Ljung-Box statistics also provide evidence of possible dependence in the first and higher moments of the return distributions. The Ljung-Box Q-statistics show that the null hypothesis of no autocorrelation is rejected for all returns on Shanghai indices and Shenzhen B-share index at lag 1 through 12 at the 1% level of significance. For Shenzhen A-share index, except the autocorrelation coefficient for lag 1 and 2, and that lag 3 are equal to zero are rejected by LB-statistics at the 10% significance level, and lag 4, 6 and 12 at the 1% level of significance. For Shenzhen Composite, the autocorrelation coefficients for lag 1 and 2 are rejected by LB-statistics at 10% level of significance, lag 3 at 5 % level of significance, and lag 4, 6 and 12 are also at the 1% level of significance. The non-zero autocorrelation of the series associated with Ljung-Box Q-statistics, which are jointly significant at 1% level at 1 and 12 degrees of freedom, clearly suggest that all return series do not follow a random walk model. The results show that the independent and identically distributed hypothesis is rejected for all the stock return series in both markets.

Our results of autocorrelation test are consistent with the previous findings in emerging markets, e.g., Harvey (1995), Poshakwale (1996), Mobarek and Keasey (2002), Hassan et al. (2006). They find significant presence of strong serial correlation in the emerging stock market returns, which indicate the presence of various imperfections in the functioning of these markets. Our results from serial autocorrelation test do not differ from previous studies on Chinese stock market efficiency either. However, contrary to Ma and Barnes (2001) have reported, we find that the autocorrelation of daily returns on the indices of each of two markets do not decay gradually as the lag length increases. In fact, we find the significant autocorrelation coefficients particularly high at lags in the beginning and in the end for both market index returns. This may suggest that the historical information embedded in longer period of lags would be as influential in determining the future price as that of information embedded in shorter lag lengths. These results clearly show the evidence of linear dependence in both Shanghai and Shenzhen markets for the full sample period 1992-2005.

Table 6. Results of the Sample Autocorrelation Coefficients and Ljung-Box Q-Statistics for the Full Sample Period

This table provides the results of the sample autocorrelation coefficients and the Ljung-Box statistics for the daily returns on the indices for the Shanghai and the Shenzhen markets for the full sample period 1992-2005. All returns are continuously compounded. ρ_k is the sample autocorrelation coefficient at lag *k*. *Q*(1) and *Q*(12) are the Ljung-Box statistic identifying the presence of first and twelfth-order autocorrelation. Under the null hypothesis of no autocorrelation, it is distributed as χ^2 with 1 and 12 degree of freedom, respectively. Values in parentheses are *p*-values.

	Shanghai stock market			Shenzhen stock market		
	A Index	B Index	Composite	A Index	B Index	Composite
ρ_1	0.044***	0.162***	0.044***	0.013	0.149***	0.029*
ρ_2	0.042***	0.006	0.042***	0.034**	0.033*	0.028*
ρ_3	0.046***	0.044***	0.043***	0.024*	0.089***	0.028*
ρ_4	0.031*	0.018*	0.028*	0.071***	0.082***	0.086***
ρ_5	0.028*	0.003	0.023*	0.012	0.021	0.013
ρ_6	-0.021	0.013	-0.021	-0.053***	0.019*	-0.045***
ρ_7	-0.010	-0.003	-0.010	-0.011	0.032*	-0.003
ρ_8	-0.022*	0.011	-0.020	-0.010	0.045***	-0.012
ρ_9	0.029*	0.015	0.027*	0.002	0.005	0.021
ρ_{10}	-0.016	0.035**	-0.017	-0.036**	0.032*	-0.028*
ρ_{11}	-0.055***	0.025*	-0.051***	-0.001	0.003	-0.008
ρ_{12}	0.035**	0.029*	0.036**	0.038**	0.022*	0.051***
Q(1)	6.889***	95.352***	6.927***	0.572	76.536***	3.001*
	(0.009)	(0.000)	(0.008)	(0.447)	(0.000)	(0.083)
Q(2)	13.303***	95.462***	13.331***	4.530	80.379***	5.885*
	(0.001)	(0.000)	(0.001)	(0.101)	(0.000)	(0.053)
Q(3)	21.065***	102.54***	19.994***	6.529*	107.96***	8.750**
	(0.000)	(0.000)	(0.000)	(0.088)	(0.000)	(0.033)
Q(4)	24.615***	103.71***	22.876***	24.016***	131.36***	35.357***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Q(6)	28.966***	104.38***	26.349***	34.137***	134.06***	43.358***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Q(12)	50.547***	115.36***	45.968***	44.530***	150.12***	58.093***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

Table 7 provides the results of the Ljung-Box Q-statistics test for the three sub-periods. Before 1996, returns on all Shanghai and Shenzhen indices are serially correlated as show in Panel A, except that Shenzhen A-share and Shenzhen Composite indices show non-significant autocorrelation coefficient at lag 1 through 3. After 1996, returns on both markets indices show again the significant autocorrelation coefficients at all lags, mostly at the 1% level significance. The autocorrelation coefficient at lag 1 and 2 are non-significant for A-share and Composite indices of both markets as shown in Panel B. The period of after the market crash in 2001-2005, Shanghai A-share, Shanghai Composite, Shenzhen A-share and Shenzhen Composite indices show no sign of autocorrelation at any lags. The finding here indicates that after the period 2001, A-share and Composite indices of both markets have become more efficient. For returns on Shanghai B-share and Shenzhen B-share indices, the Ljung-Box statistics are mostly significant at the 1% level for the entire three sub-periods. This result is consistent with the previous studies in Chinese stock market, that the behavior of B-shares displays more violations of the random walk hypothesis than A-shares in both Chinese stock markets.

Table 7. Results of the Ljung-Box Q-statistics for the Three Sub-periods

This table shows the results of the Ljung-Box Q-statistics for the three sub-periods. All returns are continuously compounded. Q(1) and Q(12) are the Ljung-Box statistic identifying the presence of first and twelfth-order autocorrelation. Under the null hypothesis of no autocorrelation, it is distributed as χ^2 with 1 and 12 degree of freedom, respectively.

	Shanghai stock market			Shenzhen stock market		
	A Index	**B Index**	**Composite**	**A Index**	**B Index**	**Composite**
Panel A: 1992:2 - 1995:12						
Q(1)	3.619*	77.083***	3.699***	0.038	68.689***	1.181
Q(2)	6.955**	80.245***	7.225**	1.584	95.296***	2.478
Q(3)	8.434**	81.259***	8.361**	2.289	101.90***	2.673
Q(4)	9.888**	81.480***	9.510***	11.055**	118.26***	16.447***
Q(6)	11.715**	83.179***	10.520*	16.855**	123.24***	22.735***
Q(12)	20.584*	95.005***	19.346*	25.096**	130.86***	34.667***
Panel B: 1996:1 - 2000:12						
Q(1)	0.473	32.266***	0.327	0.122	28.144***	0.308
Q(2)	0.490	32.710***	0.345	1.837	29.628***	1.600
Q(3)	12.193***	37.357***	11.867***	16.176***	37.129***	14.835***
Q(4)	12.358**	37.427***	12.076**	18.521***	41.056***	19.641***
Q(6)	13.657**	38.434***	13.200**	20.189***	42.649***	20.564***
Q(12)	36.592***	42.260***	35.973***	31.475***	47.920***	32.161***
Panel C: 2001:1 - 2005:12						
Q(1)	0.168	9.712***	0.128	1.143	15.036***	0.924
Q(2)	1.138	9.791***	1.017	1.746	15.261***	1.511
Q(3)	1.379	10.661**	1.203	2.638	31.407***	2.396
Q(4)	1.384	12.466**	1.246	2.642	47.424***	2.420
Q(6)	3.685	16.889**	3.329	3.402	58.838***	3.087
Q(12)	8.516	24.664**	8.319	8.033	87.596***	8.058

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

5.4 Runs Test

The results of the runs tests for returns on indices for the Shanghai and Shenzhen market are reported in Table 8. For the full period in Panel A, the runs test clearly shows that both Shanghai and Shenzhen markets are weak-form inefficient. All of the estimated Z-values are significant at the 1% level for returns on Shanghai B-share index and all Shenzhen indices, and at the 10% level for returns on Shanghai A-share and Shanghai Composite indices. The significant negative Z-values for returns on all indexes indicates that the actual number of runs falls short of the expected number of runs under the null hypothesis of return independence as shown in Panel A. The negative Z-values for returns on all indexes are also indicative of positive serial autocorrelation, which is consistent with the results from serial correlation tests.

For the first sub-period (1992-1995) in Panel B, Z-values are significant at the 1% level only for returns on Shanghai B and Shenzhen B indices. For the second sub-period, i.e., during the period of rapid growth in 1996 to 2000, the estimated Z-values are again significant at the 1% level for returns on Shanghai B-share and Shenzhen B-share indices. Estimated Z-values for returns on Shanghai A-share and Shanghai Composite indices are non-significant, but for Shenzhen A-share and Shenzhen Composite are significant at the 1% level of significance. For the third sub-period (2001-2005) in Panel D, except for Shenzhen Composite index, the estimated Z-values are significant at level 5% of significance for returns on Shenzhen B-share indices, and at the 10% level of significance for Shenzhen A-share index and for all returns series in Shanghai.

Similar to results from serial correlation test, the estimated value for return series of B-share indices have higher values than those of A-share indices in both markets. However, the runs test results for the three sub-periods seem to differ from the serial correlation test results. Results from runs test show that Shanghai A-share and Composite indices are non-significant in the periods 1992-1995 and 1996-2000, whereas Shenzhen A-share are non-significant in 1992-1995 and Shenzhen Composite in 1992-1995 and 2001-2005. Results from Ljung-Box Q-Statistics show that A-share and Composite in both markets are non-significant after 2001. For the full period, the runs test results for the Shanghai and Shenzhen markets are consistent with the results from the serial correlation test. The results from both runs and serial correlation tests indicate that the return on indices for both Shanghai and Shenzhen markets do not a random walk process.

Table 8. Results of the Non-parametric Runs Test

The table shows the results of runs tests for each index of the Shanghai and the Shenzhen markets for the full sample period 1992-2005 and the three sub-periods. A total case denotes the number of observations and total number of runs is a measure of randomness since too many or too few runs indicates dependence between observations. Case<mean denotes the number of cases below mean, while Case ≥mean indicates the number greater than or equal to the mean. It is a positive change when return is greater than the mean, a negative change when the return is less than the mean and zero when the return equals to the mean. The test statistics Z is with its observed significance level.

Times series	Total cases	Cases < mean	Cases≥ mean	Number of runs	Z-statistic	*p*-value
Panel A: Full period						
Shanghai						
A Index	3616	1658	1958	1736	-2.208*	0.043
B Index	3616	1829	1787	1621	-6.246***	0.000
Composite	3616	1649	1967	1740	-1.844*	0.065
Shenzhen						
A Index	3455	1611	1844	1613	-3.680***	0.000
B Index	3455	1482	1973	1485	-7.246***	0.000
Composite	3616	1669	1947	1657	-4.729***	0.000
Panel B: 1992:2 - 1995:12						
Shanghai						
A Index	1006	457	549	502	0.140	0.888
B Index	1006	506	500	429	-4.731***	0.000
Composite	1006	452	554	506	0.457	0.648
Shenzhen						
A Index	845	411	434	418	-0.357	0.748
B Index	845	447	398	356	-4.564***	0.000
Composite	1006	488	518	484	-1.235	0.217
Panel C: 1996:1 - 2000:12						
Shanghai						
A Index	1305	612	693	627	-1.334	0.182
B Index	1305	558	747	572	-3.836***	0.000
Composite	1305	611	694	625	-1.438	0.150
Shenzhen						
A Index	1305	622	683	595	-3.168***	0.002
B Index	1305	554	751	551	-4.967***	0.000
Composite	1305	621	684	585	-3.718***	0.000
Panel D: 2001:1 - 2005:12						
Shanghai						
A Index	1305	702	603	617	-1.824*	0.068
B Index	1305	671	634	622	-1.717*	0.086
Composite	1305	705	600	619	-1.688*	0.091
Shenzhen						
A Index	1305	719	586	615	-1.775*	0.076
B Index	1305	583	722	610	-2.022**	0.043
Composite	1305	719	586	627	-1.104	0.270

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

5.5 Variance Ratio

The results of the variance ratio tests for Shanghai and Shenzhen markets for the full sample period and the three sub-periods are reported in Table 9. VR(q) represents the variance ratio of the returns, and Z(q) and Z*(q) represent the statistics of the variance ratio under the assumption of homoscedasticity and heteroscedasticity, respectively. The variance ratio test is conducted for various lags of q (i.e., 2, 4, 8, 12 and 16 days) for each index.

For the full period reported in Panel A, all the statistics of Z(q), with the exception of Shenzhen A-share index in interval 2, the null hypothesis of a random walk is rejected at either the 1% or 5% level of significance. However, rejection of the null hypothesis under homoscedasticity could result from heteroscedasticity and/or autocorrelation in the return series. After a heteroscedasticity is calculated, the null hypothesis is rejected for both B-share indices in all intervals. The null hypothesis of heteroscedasticity is also rejected for Shenzhen Composite in interval 8 and 16. The null hypothesis of heteroscedasticity is not rejected for Shanghai A-share, Shanghai Composite and Shenzhen A-share. This indicates that the rejection of the null hypothesis of a homoscedasticity random walk could be the result, at least in part, of heteroscedasticity in the returns, and cannot be assigned exclusively to the autocorrelation in returns. The variance ratios of returns on indices are greater than one for all q and seem to be increasing with q, indicating some form of positive autocorrelation. This result is similar to findings of Campbell et al. (1997), and Ma and Barnes (2001). This non-random walk pattern based on variance ratio test is also consistent with the findings of serial correlation and run tests for the full sample period.

For the first sub-period (1992-1995), results reported in Panel B show that all the statistics of Z(q), with the exception of Shenzhen A-share index in all intervals, the random walk hypothesis is again rejected for the indices of both markets. The null hypothesis of heteroscedasticity is not rejected for Shenzhen A-share index in all intervals. The null hypothesis of heteroscedasticity is again rejected for both B-share indices in all intervals, but for Shanghai A-share, Shanghai Composite and Shenzhen Composite only in 16 intervals. The variance ratios of returns on the indices, excluding Shenzhen A-share index, are greater than one for all q and are increasing as the interval length of q enlarges in the same way as in the full period.

For the second sub-period (1996-2000) in Panel C, the results of Z(q) and Z*(q) statistics show that returns on Shanghai A-share and Shanghai Composite indices exhibit a random walk pattern, whereas the random walk hypothesis is rejected for the four remaining return series. Z(q) and Z*(q) statistics indicate that the random walk is again rejected for both B-share indices in all intervals. In the case of Shenzhen A-share and Composite, the null hypothesis of homoscedasticity random walk is rejected in 4, 8, 12 and 16 intervals, and the null hypothesis of heteroscedasticity random walk is rejected in 8 and 16 intervals. The variance ratios of returns on indices, with the exception of Shanghai A-share and Shanghai Composite indices in interval 2, 12 and 16, are greater than one, but slightly smaller with stronger rejection than the first sub-period.

For the third sub-period (2001-2005) in Panel D, with the exception of Shanghai B-share and Shenzhen B-share, Z(q) and Z*(q) statistics fails to reject the null hypothesis of a random walk for Shanghai A-share, Shanghai Composite, Shenzhen A-share and Shenzhen Composite indices. The results confirm the prior findings of serial correlation, that after 2001 these indices have become more efficient. The variance ratio test rejects the null hypothesis of a random walk at the 1% level of significance for returns on Shanghai B-share and Shenzhen B-share indices for the full periods and all the three sub-periods.

Table 9. Results of the Variance Ratio Test

The table presents results of the variance ratio tests for returns on indices for the Shanghai and Shenzhen markets for the full sample period and the three of sub-periods. Estimates of variance ratios, VR(q), the statistics Z(q) and Z*(q) for q=2, 4, 8, 12 & 16 days aggregation intervals periods are reported below. N denotes the number of observations; q is the interval of the observations; VR(q) is estimated variance ratios, and Z(q) and Z*(q) are the asymptotic normal test statistics under homoscedasticity and heteroscedasticity, respectively.

			Holding period of (q) days				
Time series	**N**		**2**	**4**	**8**	**12**	**16**
Panel A: Full period							
Shanghai							
A Index	3616	**VR(q)**	1.044	1.131	1.237	1.250	1.258
		Z(q)	2.646***	4.211***	4.808***	4.005***	3.520***
		Z*(q)	0.800	1.273	1.454	1.211	1.713*
B Index	3616	**VR(q)**	1.162	1.271	1.361	1.450	1.515
		Z(q)	9.742***	8.711***	7.329***	7.223***	7.036***
		Z*(q)	4.167***	3.726***	3.134***	3.089***	4.843***
Composite	3616	**VR(q)**	1.044	1.130	1.226	1.236	1.245
		Z(q)	2.646***	4.162***	4.594***	3.785***	3.345***
		Z*(q)	0.801	1.260	1.391	1.146	1.630
Shenzhen							
A Index	3455	**VR(q)**	1.013	1.066	1.155	1.145	1.159
		Z(q)	0.764	2.058**	3.070***	2.276**	2.117**
		Z*(q)	0.308	0.829	1.237	0.917	1.373
B Index	3455	**VR(q)**	1.149	1.301	1.537	1.685*	1.789*
		Z(q)	8.758***	9.457***	10.666***	10.737***	10.539***
		Z*(q)	3.179***	3.433***	3.872***	3.898***	6.157***
Composite	3616	**VR(q)**	1.029	1.115	1.200	1.232	1.276
		Z(q)	1.744*	3.680***	4.070***	3.721***	3.773***
		Z*(q)	1.120	1.558	1.724*	1.576	2.572***
Panel B: 1992:2 - 1995:12							
Shanghai							
A Index	1006	**VR(q)**	1.060	1.166	1.293	1.329	1.346
		Z(q)	1.903*	2.814***	3.136***	2.785***	2.494***
		Z*(q)	0.937	1.386	1.544	1.371	1.977**
B Index	1006	**VR(q)**	1.276	1.486	1.675	1.820	1.960
		Z(q)	8.754***	8.240***	7.235***	6.934***	6.963***
		Z*(q)	8.085***	7.610***	6.682***	6.404***	10.350***
Composite	1006	**VR(q)**	1.061	1.168	1.284	1.317	1.336
		Z(q)	1.935*	2.840***	3.045***	2.682***	2.418***
		Z*(q)	0.997	1.464	1.569	1.382	2.006**
Shenzhen							
A Index	845	**VR(q)**	1.007	1.039	1.111	1.093	1.084
		Z(q)	0.203	0.606	1.093	0.721	0.557
		Z*(q)	0.144	0.429	0.775	0.511	0.636
B Index	845	**VR(q)**	1.285	1.649	2.091	2.340	2.524
		Z(q)	8.285***	10.076***	10.721***	10.386***	10.066***
		Z*(q)	5.826***	7.086***	7.539***	7.303***	11.392***
Composite	1006	**VR(q)**	1.034	1.080	1.203	1.259	1.311
		Z(q)	1.708*	1.356	2.177**	2.194**	2.244**
		Z*(q)	0.752	0.946	1.518	1.530	2.519***

Table 9. (continued)

Time series	N		Holding period of (q) days 2	4	8	12	16
Panel C: 1996:1 - 2000:12							
Shanghai							
A Index	1305	**VR(q)**	0.981	1.015	1.071	0.977	0.933
		Z(q)	-0.686	0.290	0.867	-0.225	-0.550
		Z*(q)	-0.555	0.234	0.701	-0.182	-0.715
B Index	1305	**VR(q)**	1.157	1.248	1.297	1.306	1.334
		Z(q)	5.672***	4.779***	3.621***	2.944***	2.739***
		Z*(q)	3.684***	3.104***	2.352***	1.912*	2.863***
Composite	1305	**VR(q)**	0.984	1.019	1.071	0.983	0.939
		Z(q)	-0.578	0.367	0.870	-0.167	-0.501
		Z*(q)	-0.471	0.299	0.709	-0.136	-0.656
Shenzhen							
A Index	1305	**VR(q)**	1.010	1.104	1.228	1.201	1.289
		Z(q)	0.361	1.999**	2.778***	1.932*	2.370***
		Z*(q)	0.260	1.439	2.001**	1.391	2.746***
B Index	1305	**VR(q)**	1.149	1.281	1.436	1.508	1.534
		Z(q)	5.383***	5.416***	5.319***	4.893***	4.386***
		Z*(q)	2.911***	2.930***	2.877***	2.647***	3.818***
Composite	1305	**VR(q)**	1.015	1.104	1.230	1.209	1.234
		Z(q)	0.542	2.008**	2.806***	2.009***	1.922*
		Z*(q)	0.435	1.613	2.254**	1.614	2.486***
Panel D: 2001:1 - 2005:12							
Shanghai							
A Index	1305	**VR(q)**	1.011	0.997	0.971	0.958	0.956
		Z(q)	0.397	-0.068	-0.357	-0.405	-0.360
		Z*(q)	0.666	-0.113	-0.599	-0.679	-0.972
B Index	1305	**VR(q)**	1.086	1.150	1.274	1.380	1.473
		Z(q)	3.107***	2.896***	3.349***	3.665***	3.880***
		Z*(q)	2.425***	2.261***	2.615***	2.861***	4.857***
Composite	1305	**VR(q)**	1.010	0.995	0.974	0.963	0.964
		Z(q)	0.361	-0.097	-0.324	-0.360	-0.299
		Z*(q)	0.610	-0.163	-0.546	-0.607	-0.811
Shenzhen							
A Index	1305	**VR(q)**	1.030	1.037	1.043	1.038	1.053
		Z(q)	1.084	0.714	0.519	0.361	0.431
		Z*(q)	0.839	1.107	0.804	0.560	1.074
B Index	1305	**VR(q)**	1.107	1.230	1.535	1.774	1.941
		Z(q)	3.685***	4.448***	6.531***	7.460***	7.724***
		Z*(q)	2.871***	3.304***	4.851***	5.541***	9.233***
Composite	1305	**VR(q)**	1.027	1.033	1.042	1.047	1.055
		Z(q)	0.975	0.628	0.507	0.452	0.451
		Z*(q)	1.528	0.983	0.794	0.707	0.138

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

All estimated values from Z(q) and Z*(q) indicate that the random walk hypothesis is strongly rejected for Shanghai and Shenzhen B-share markets for all five intervals examined. This finding suggests that the rejection of the random walk may be due to autocorrelation. The rejection of the null hypothesis of the homoscedastic but not the heteroscedastic random walk is found for Shanghai A-share and Shanghai Composite. This finding indicates the rejection of the null hypothesis of the random walk may be due to heteroscedasticity and therefore both of them meet at least some of the requirements of a strict random walk. In the case of Shenzhen A-share and Shenzhen Composite, the rejection of the null hypothesis is not altogether clear, but it seems that part of the rejection is due to heteroscedasticity and/or autocorrelation in the returns.

The overall findings based on variance ratio test indicate that Shanghai A-share and Shanghai Composite markets have become more efficient over time. Shenzhen A-share and Shenzhen Composite markets also show a very similar result. The empirical findings from a variance ratio test of a random pattern during the 1996-2000 in the Shanghai A-share and Shenzhen A-share markets coincide with those of Lima and Tabak (2004) who found that both markets exhibit a random walk. However, the findings here contradict the Ma and Barnes (2001) and Darrat and Zhong (2000) findings of randomness in both Shanghai and Shenzhen stock markets.

5.6 Day-of-the-Week Effect

Descriptive statistics for both market daily returns by day of the week is provided in Table 10. All of the six index series have negative mean returns on Tuesday and Thursday. Shanghai A-share and Shanghai Composite have also negative return on Wednesday. All of the six index series have positive mean returns on Monday, and except Shenzhen B-share, all of the five index series have positive mean returns on Friday as well. The standard deviation does not seem to differ from day of the week on all of the cases.

Table 10. Descriptive Statistics for Daily Index Returns by Day of the Week

The table provides descriptive statistics of daily index returns on Shanghai and Shenzhen market for different days for the full sample period 1992-2005. N denotes the observations of each day of week, and mean return, maximum, minimum and standard deviation are calculated for each day of week.

Time series	Monday b_1	Tuesday b_2	Wednesday b_3	Thursday b_4	Friday b_5
Panel A: Shanghai					
A Index					
Mean return	0.0016	-0.0014	-0.0005	-0.0024	0.0012
Maximum	0.1843	0.1174	0.1179	0.0762	0.1460
Minimum	-0.1162	-0.3035	-0.7452	-0.2014	-0.3085
Standard deviation	0.0233	0.0263	0.0376	0.0226	0.0297
N	723	723	723	723	724
B Index					
Mean return	0.0009	-0.0004	0.0006	-0.0010	0.0008
Maximum	0.0987	0.0972	0.1372	0.1308	0.1029
Minimum	-0.1153	-0.0942	-0.0953	-0.1382	-0.1218
Standard deviation	0.0205	0.0203	0.0215	0.0204	0.0239
N	723	723	723	723	724
Composite					
Mean return	0.0015	-0.0013	-0.0005	-0.0023	0.0010
Maximum	0.1791	0.1133	0.1125	0.0745	0.1401
Minimum	-0.1114	-0.2616	-0.7192	-0.1937	-0.2886
Standard deviation	0.0223	0.0250	0.0362	0.0217	0.0285
N	723	723	723	723	724
Panel B: Shenzhen					
A Index					
Mean return	0.0007	-0.0011	0.0008	-0.0010	0.0006
Maximum	0.1963	0.1478	0.1023	0.0980	0.1160
Minimum	-0.1250	-0.1517	-0.2594	-0.1106	-0.2958
Standard deviation	0.0210	0.0214	0.0235	0.0201	0.0281
N	691	691	691	691	691
B Index					
Mean return	0.0012	-0.0001	0.0001	-0.0012	-0.0005
Maximum	0.1007	0.1670	0.0872	0.1597	0.1053
Minimum	-0.0973	-0.0953	-0.1034	-0.1380	-0.1247
Standard deviation	0.0203	0.0204	0.0212	0.0214	0.0245
N	691	691	691	691	691
Composite					
Mean return	0.0004	-0.0010	0.0005	-0.0012	0.0002
Maximum	0.1888	0.1353	0.1017	0.1040	0.1304
Minimum	-0.1163	-0.1335	-0.2491	-0.1047	-0.2722
Standard deviation	0.0208	0.0201	0.0225	0.0195	0.0280
N	723	723	723	723	724

Table 11 provides test results for the day of the week effect on both Chinese stock markets for the full sample period 1992 to 2005.

Table 11. Results of Test for the Day-of-the-Week Effect

The table reports tests results for day of the week effect on Shanghai and Shenzhen index returns for the full sample period 1992-2005. The first rows for each day of the week are the coefficients b_i and the second are the values of t-statistic. The F statistic test for the day of the week effect; that the coefficients are not significantly different from zero. [a] and [b] numbers in parentheses are *p*-values for t-statistic and F-statistic, respectively.

Time series	Monday b_1	Tuesday b_2	Wednes-day b_3	Thursday b_4	Friday b_5	F-value
Panel A: Shanghai						
A Index	0.0016	-0.0014	-0.0005	-0.0020	0.0010	2.164*
t-value	1.526	-1.342	-0.519	-2.317**	1.021	[0.055][b]
	(0.1270)[a]	(0.1795)	(0.6031)	(0.0205)	(0.3069)	
B Index	0.0009	-0.0004	0.0006	-0.0010	0.0008	0.907
t-value	1.077	-0.480	0.754	-1.200	1.063	[0.476]
	(0.2814)	(0.6309)	(0.4506)	(0.2300)	(0.2879)	
Composite	0.0015	-0.0012	-0.0005	-0.0023	0.0010	2.059*
t-value	1.471	-1.271	-0.484	-2.303**	0.988	[0.067]
	(0.1415)	(0.2039)	(0.6286)	(0.0213)	(0.3232)	
Panel B: Shenzhen						
A Index	0.0007	-0.0012	0.0008	-0.0010	0.0006	0.977
t-value	0.779	-1.256	0.881	-1.176	0.737	[0.430]
	(0.4383)	(0.2090)	(0.3785)	(0.2395)	(0.4613)	
B Index	0.0012	-0.0001	0.0001	-0.0011	-0.0004	0.930
t-value	1.493	-0.152	0.123	-1.438	-0.562	[0.460]
	(0.3454)	(0.8794)	(0.9020)	(0.1504)	(0.5744)	
Composite	0.0003	-0.0010	0.0005	-0.0012	0.0002	0.836
t-value	0.437	-1.199	0.564	-1.482	0.198	[0.524]
	(0.6619)	(0.2304)	(0.5726)	(0.1385)	(0.8433)	

***, ** and * indicate statistical significance at the 1%, 5% and 10% levels.

Results from Table 11 shows that Shanghai A-share and Shanghai Composite indices are found to exhibit the significant day of the week effects. Shanghai A-share and Shanghai Composite have significant negative Thursday average returns. Based on the corresponding t-values, the negative average return, significant at the 5% level, is on Thursday for Shanghai A-share index and Shanghai Composite index. Our results seem to contradict the previous findings of Mookerjee and Yu (1999), and Gao and Kling (2005), who find that Mondays show significantly negative average returns. However, our findings did no show weaker Monday effect on both markets, but instead we find Thursdays to be weaker compared to rest of the days of the week. They also find significantly positive average returns on Fridays, but our results show that none of return series has significant positive returns on day of the week.

The F-value corresponding to Shanghai A-share and Shanghai Composite indices are 2.164 and 2.059 respectively. As a result, the null hypothesis that there is no difference in average returns between the days of the week is rejected at the 10% significance level. Our results indicate that day of the week effect exist on Shanghai A-share and Shanghai Composite indices. However, based on results of F-statistics, we fail to reject the null hypothesis for all Shenzhen indices and Shanghai B-share index, and therefore we conclude that Shenzhen market and Shanghai B-share index market do not display a day of the week effect. Hereby, only Shanghai A-share and Composite index markets exhibit the day-of-the-week effects, which is clear evidence of violations of the random walk.

It is quite evident that findings regarding test for day-of-the-week effect on the Shanghai stock market are different from findings on the Shenzhen stock market, although market microstructure features are similar on both exchanges. One possible explanation for this difference may be a result of differences in types of traders on the two markets. Also of note, results show that returns on B-share indices does not differ from day of the week. This findings is somehow surprising, since based on all statistical test results, it would be expected that B-share might exhibit significant positive returns on certain day of the week. B-share markets are yet found to be more predictable than A-share markets.

6. CONCLUSIONS

Theoretical basis of the weak-form efficient market hypothesis states that successive stock prices or returns are independently and identically distributed that past stock prices have no predictive content to forecast future stock prices. Following the theoretical literature, empirical studies on the weak-form efficient market hypothesis in emerging markets have been intensively investigated, especially in recent years. The empirical evidence obtained from these studies is mixed. Indeed, some studies show evidence empirical results that reject the null hypothesis of weak-form market efficiency, while others report evidence to support the weak-form efficiency. Based on the theoretical and empirical literature that is reviewed in this study, the weak-form market efficiency in the context of an emerging market, namely Chinese stock market is investigated.

This study examines the random walk hypothesis and tests the weak-form efficiency of two major stock markets in China using daily data of three Shanghai index series and three Shenzhen index series from the period 1992 to 2005. Both Chinese stock markets have experienced tremendous changes during this period. Therefore, we have examined the weak-form efficient market hypothesis over three sub-periods in order to analyze whether the Chinese stock market exhibits a trend towards increased efficiency over time. We have also investigated the day-of-the-week effect on both stock exchanges in order to find out whether Chinese stock market returns violate the random walk hypothesis. Four different statistical methods, namely a serial correlation test, a runs test, a variance ratio test, and an Augmented Dickey-Fuller and Phillips-Perron unit root tests are employed in this study.

The empirical results of this study indicate that stock returns in both Chinese stock markets do not behave in a manner consistent with the weak-form of efficient market hypothesis. The Augmented Dickey-Fuller unit root test shows the existence of a unit root in all of the six index series. The results obtained from the serial correlation, variance ratio and runs tests show strong evidence of a non-random walk pattern in both Chinese stock markets. The results from three of these tests indicate the presence of positive autocorrelation in daily return series in all index series.

For the full sample period, three of these tests are consistent in rejection of the random walk hypothesis but are not completely consistent for three sub-periods examined. A non-parametric runs test shows evidence support to the weak-form efficiency in Shanghai A-share and Composite during 1992 to 2000, and Shenzhen Composite during 2001 to 2005. The results of variance ratio and serial correlation test both show evidence support to the weak-form efficiency in A-share and Composite for both markets after 2001. In contrast to previous results on Chinese stock market, our findings suggest that both markets have become more efficient after 2001. Steps taken by China Securities Regulatory Committee (CSRC) to promote transparency and efficiency in the stock markets from the period 1998 to 2001 may explain evidence to support the weak-form efficiency during latter period. However, our results are in line with the previous studies, suggesting that B-share markets display more violation of the random walk behavior compared with A-share markets. The potential predictability found in B-share markets may due to thin trading, as previous studies have documented. Our results also suggest that efficiency between Shanghai and Shenzhen markets does not differ from each other significantly.

The day-of-the-week effect test results indicate, with the exception of Shanghai A-share and Shanghai Composite, that there is no such effect on Shanghai B-share and Shenzhen stock market. Our results test for the day-of-the-week effect does not conform to the previous studies; suggesting that returns on Monday are significant negative and Friday are significant positive. We find that Shanghai A-share and Shanghai Composite exhibit significant negative returns on Thursday. This result suggests that Shanghai stock market returns display more violations of the random walk pattern than Shenzhen stock market, therefore indicating the Shanghai stock market being less efficient compared with Shenzhen stock market.

The empirical results of this study, suggest that the Chinese stock market are associated with the random walks required for the assumption of weak-form market efficiency is not unique but similar to earlier studies on the Chinese stock market. Overall, the results of this study are also consistent with the general assumption that the emerging stock markets are not as informationally efficient as their developed countries are. Like any emerging markets, Chinese stock market also possesses many of the features that are so characteristics of emerging stock markets. Chinese stock market also possesses many of its own unique features such as segmentation of two shares and political environments, which may be the causes of market inefficiency. Compared with the develop stock markets in the U.S.A and the UK, the Chinese stock market has a short history of only ten years. Given the fact that the Chinese stock market has experienced tremendous changes over the past decade, it is reasonable to expect the Chinese stock market to have a lower level of informational efficiency than a well-developed market and more mature emerging stock markets.

Further research can be constructed to investigate whether the Chinese stock market is weak-form efficient using weekly or monthly data and different indices. Alternatively, using the largest and liquid stocks might have more power to detect the weak-form efficiency of Chinese stock market. Another fruitful area of research can be testing whether any trading rules can make profitable investment strategy for the test of weak-form of efficient market hypothesis. Finally, possible sources of calendar anomalies could be also investigated.

REFERENCES

Abraham, A., Seyyed, F. J., and Alsakran, S. A. (2002): "Testing the Random Walk Behavior and Efficiency of the Gulf Stock Markets". *The Financial Review*, vol. 37, 469-480.

Abeysekera, S. (2001): "Efficient Market Hypothesis and the Emerging Capital Markets in Sri Lanka: Evidence from the Colombo Stock Exchange - A Note". *Journal of Business Finance & Accounting*, vol. 28, no. 1 & 2, 249-261.

Abrosimova, N., Dissanaike, G., and Linowski, D. (2005): "Testing the Weak-Form Efficiency of the Russian Stock Market". *Social Science Research Network (SSRN) Working Paper*. [E-document] [Retrieved January 7, 2006] From: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=302287

Akinkugbe, O. (2005): "Efficiency in Botswana Stock Exchange: An Empirical Analysis". *The Business Review*, vol. 4, no. 2, 223-230.

Al-Loughani, N., and Chappell, D. (1997): "On the validity of the weak-form efficient markets hypothesis applied to the London stock exchange". *Applied Financial Economics*, vol. 7, 173-176.

Appiah-Kusi, J., and Menyah, K. (2003): "Return predictability in African stock markets". *Review of Financial Economics*, vol. 12, 247-270.

Antoniou, A., Ergul, N., and Holmes, P. (1997): "Market efficiency, thin trading and non-linear behavior: evidence from an emerging market". *European Financial Management*, vol. 3, no. 2, 175-190.

Bailey, W. (1994): "Risk and return in China's new stock markets: some preliminary evidence". *Pacific Basin Finance Journal*, vol. 1, 243-260.

Ball, R. (1994): “The Development, Accomplishments and Limitations of the Theory of Stock Market Efficiency”. *Managerial Finance*, vol. 20, no. 2, 3-48.

Ball, R., and Brown, P. (1968): “An empirical evaluation of accounting income numbers”. *Journal of Accounting Research*, vol. 6, 159-178.

Barnes, P. (1986): “Thin Trading and Stock Market Efficiency: The case of the Kuala Lumpur Stock Exchange”. *Journal of Business Finance & Accounting*, vol. 13, no. 4, 609-617.

Beaver, W. H. (1981): “Market Efficiency”. *Accounting Review*, vol. 56, 23-37.

Brooks, C. (2004): *Introductory econometrics for finance*. Fifth Edition. Cambridge: Cambridge University Press.

Butler, C. K., and Malaikah, S. J. (1992): “Efficiency and inefficiency in thinly traded stock markets: Kuwait and Saudi Arabia”. *Journal of Banking and Finance*, vol. 16, 197-210.

Campbell, J. Y., Lo, A. W., and MacKinlay, A. C. (1997): *The Econometrics of Financial Markets*. Second Edition. Princeton: Princeton University Press.

Chang, T., Fawson, C., Glover, T. F., and Fang, W. (1996): “The weak-form efficiency of the Taiwan share market”. *Applied Economics Letters*, vol. 3, 663-667.

Chang K. P., and Ting, K. S. (2000): “A variance ratio test of the random walk hypothesis for Taiwan’s stock market”. *Applied Financial Economics*, vol. 10, no. 5, 525.

Chan, K. C., Gup, B. E., and Pan, M. P. (1997): “International Stock Market Efficiency and Integration: A Study of Eighteen Nations”. *Journal of Business Finance & Accounting*, vol. 24, no. 6, 803-813.

Cheng, K. X. (2000): “The microstructure of the Chinese stock market”. *China Economic Review*, vol. 11, 79-97.

Cheung, C.K., and Coutts, A. J. (2001): “A note on weak form market efficiency in security prices: evidence from the Hong Kong stock exchange”. *Applied Economics Letters*, vol. 8, 407-410.

China Securities Regulatory Commission (CSRC) official website: http://www.csrc.gov.cn/en

Choudhry, T. (1994): “Stochastic trends and stock prices: an international inquiry”. *Applied Financial Economics*, vol. 4, 383-390.

Cuthbertson, K. (1996): *Quantitative financial economics*. England: John Wiley & Sons Ltd.

Darrat, A. F., and Zhong, M. (2000): “On testing the random-walk hypothesis: a model-comparison approach”. *The Financial Review*, vol. 35, no. 3, 105-124.

Dickey, D. A., and Fuller, W. A. (1981): “Likelihood ratio statistics for autoregressive time series with a unit root”. *Econometrica*, vol. 49, 1057-1072.

Dickinson, J. P., and Muragu, K. (1994): “Market Efficiency in Developing Countries: A case study of the Nairobi Stock exchange”. *Journal of Business Finance and Accounting*, vol. 21, no. 1, 133-150.

Dimson, E., and Mussavian, M. (1998): “A brief of history of market efficiency”. *European Financial Management*, vol. 4, no. 1, 91-193.

Dow Jones Indexes (2002): “China Stock Market in Global Perspective”. September 2002. [E-document] [Retrieved July 16, 2006]. From: http://averages.dowjones.com/mdsidx/downloads/china_mkt_WP.pdf

Enders, W. (2004): *Applied Econometric Time Series*. Second Edition. New York: John Wiley & Sons Ltd.

Engel, C., and Morris, C. S. (1991): “Challenges to Stock Market Efficiency: Evidence from Mean Reversion Studies”. *Economic Review - Federal Reserve Bank of Kansas City*, vol. 76, no. 5, 21-35.

Eviews (2004): *Eviews 5 User’s Guide*. U.S.A: Quantitative Micro Software, LLC.

Fama, E. F. (1965): ”The Behaviour of Stock Market Prices”. *Journal for Business*, vol. 38, 34-105.

Fama, E. F. (1970): ”Efficient Capital Markets: A Review of Theory and Empirical Work”. *Journal of Finance*, vol. 25, no. 2, 283-417.

Fama, E. F. (1991): “Efficient Capital Market: II”. *Journal of Finance*, vol. 5, 1575-1617.

Fama, E. F. (1995): “Random walks in stock market prices”. *Financial Analyst Journal*, vol. 21, no. 5, 55-59.

Fama, E. F. (1998): ”Market efficiency, long-term returns, and behavioral finance”. *Journal of Financial Economics*, vol. 49, 283-206.

Fama, E., and Blume, M. (1966): “Filter Rules and Stock Market Trading Profiles”. *Journal of Business*, vol. 39, 226-241.

Fama, E. F., and French, K. R. (1988): “Permanent and temporary components of stock prices”. *Journal of Political Economy*, vol. 96, no. 2, 246-73.

Fama, E., Jensen, M., and Roll, R. (1969): “The Adjustment of Stock Prices to New Information”. *International Economic Review*, vol. 10, 1-21.

Findlay, M. C., and Williams, E. E. (2000): ”A fresh look at the efficient market hypothesis: How the intellectual history of finance encouraged a real ’fraud-on-the-Market’”. *Journal of Post Keynesian Economics*, vol. 23, no. 2, 181-199.

Gao, L., and Kling, G. (2005): “Calendar Effects in Chinese Stock Market”. *Annals of Economics and Finance*, vol. 6, 75-88.

Gilmore, C. G., and McManus, G. M. (2003): “Random Walk and Efficiency Tests of Central European Equity Markets”. *Managerial Finance*, vol. 29, no. 4, 42-61.

Granger, C. W. J., and Morgenstern, O. (1963): “Spectral analysis of New York stock market prices”. *Kyklos*, vol. 16, 1-27.

Green, S. (2003): *China’s Stockmarket: A Guide to its Progress, Players and Prospects*. Second Edition. England: St Edmundsbury Press.

Groenewold, N. (1997): “Share market efficiency: tests using daily data for Australia and New Zealand”. *Applied Financial Economics*, vol. 7, 645-657.

Groenewold, N., Tang, S. H. K., and Wu, Y. (2003): "The efficiency of the Chinese stock market and the role of the banks". *Journal of Asian Economics*, vol. 14, 593-609.

Grossmann, S. J., and Stiglitz, J. E. (1980): "On the Impossibility of Informationally efficient market". *Journal of Finance*, vol. 31, 573-538.

Harvey, C. R. (1995): "Predictable Risk and Return in Emerging Markets". *Review of Financial Studies*, vol. 8, no. 3, 773-816.

Hassan, K. M., Al-Sultan, W., and Al-Saleem, J. A. (2003): "Stock Market Efficiency in the Gulf Cooperation Council Countries (GCC): The Case of Kuwait Stock Exchange". *Scientific Journal of Administrative Development*, vol. 1, no. 1.

Hassan, K. M., Haque, M., and Lawrence, S. (2006): "An Empirical Analysis of Emerging Stock Markets of Europe". *Quarterly Journal of Business and Economics*, vol. 45, no. 1 & 2, 31-52.

Huang, B. N. (1995): "Do Asian stock markets follow random walks: Evidence from the variance ratio test". *Applied Financial Economics*, vol. 5, no. 4, 251-256.

International Financial Corporation's (IFC) Emerging Stock Markets Fact Book 1999.

Jensen, M. C. (1978): "Some anomalous evidence regarding market efficiency". *Journal of Financial Economics*, vol. 6, 95-101.

Karemera, D., Ojah, K., and Cole, J. A. (1999): “Random walks and market efficiency tests: Evidence from emerging equity markets”. *Review of Quantitative Finance and Accounting*, vol. 13, no. 2, 171-188.

Khaled, M., and Islam, A. (2005): “Test of Weak-Form Efficiency of the Dhaka Stock Exchange”. *Journal of Business Finance & Accounting*, vol. 32, no. 7 & 8, 1613-1624.

Latham, M. (1986): “Informational efficiency and information subsets”. *Journal of Finance*, vol. 41, 39-52.

Laurence, M. M. (1986): “Weak-form efficiency in the Kuala Lumpur and Singapore Stock Markets”. *Journal of Banking and Finance*, vol. 10, 431-445.

Laurence, M., Cai, F., and Qian, S. (1997): “Weak-form efficiency and causality tests in Chinese stock markets”. *Multinational Finance Journal*, vol. 1, no. 4, 291-307.

Lee, C. F., Chen, G. M., and Rui, O. M. (2001): “Stock returns and volatility on China’s stock markets”. *Journal of Financial Research*, vol. 24, no. 4, 523-543.

Lee, U. (1992): “Do Stock Prices Follow Random Walk? Some International Evidence”. *International Review of Economics and Finance*, vol. 1, no. 4, 315-327.

Leroy, S. F. (1989): “Efficient Capital Markets and Martingales”. *Journal of Economic Literature*, vol. 27, no. 4, 1583-1621.

Lima, E. J., and Tabak, B. M. (2004): “Tests of the random walk hypothesis for equity markets: evidence from China, Hong Kong and Singapore”. *Applied Economic Letters*, vol. 11, 255-258.

Liu, X., Song, H., and Romilly, P. (1997): “Are Chinese stock markets efficient? A cointegration and causality analysis”. *Applied Economics Letters*, vol. 4, 411-415.

Lo, A. W., and MacKinlay, A. C. (1988): “Stock market prices do not follow random walks: Evidence from a simple specification test”. *Review of Financial Studies*, vol. 1, no. 1, 41-66.

Ma, S., and Barnes, M. L. (2001): “Are China’s Stock Markets Really Weak-form Efficient?” Centre for International Economic Studies, *Discussion Paper* No. 0119, May 2001. Adelaide University, Australia. [E-document] [Retrieved October 26, 2005] From:http://www.adelaide.edu.au/cies/ papers/0119.pdf

Malkiel, B. G. (2003): “The Efficient Market Hypothesis and Its Critics”. *Journal of Economic Perspectives*, vol. 17, no. 1, 59-82.

Miller, M. H., Muthuswamy, J., and Whaley, R. E. (1994): “Mean reversion of Standard and Poor’s 500 index basis changes: arbitrage-induced or statistical illusion? *Journal of Finance*, vol. 49, 479-513.

Mobarek, A., and Keasey, K. (2002): “Weak-Form Market Efficiency of and Emerging Market: Evidence from Dhaka Stock Market of Bangladesh”. [E-document] [Retrieved October 26, 2005] From: http://www.bath.ac.uk/centers/ CDS/Enbs-papers/Mobarek_new.htm.

Mookerjee, R., and Yu, Q. (1999): “Empirical Analysis of the Equity Markets in China”. *Review of Financial Economics*, vol. 8, 41-60.

Moustafa, M. A. (2004): “Testing the Weak-Form Efficiency of the United Arab Emirates Stock Market”. *International Journal of Business*, vol. 29, no. 3, 310-325.

Norges Bank, Petroleum Fund-Article (2006): “Investment in the Chinese equity market”. [E-document] [Retrieved July 16, 2006]. From: http://www.norges-bank.no/english/petroleum_fund/articles/2005/China/

Ojah, K., and Karemera, D. (1999): “Random Walk and Market Efficiency Tests of Latin American Emerging Equity Markets: A Revisit”. *The Financial Review*, vol. 34, no. 2, 57-72.

Osborne, M. F. (1962): “Periodic structure in the Brownian motion of stock prices”. *Operations Research*, vol. 10, 345-379.

Parkinson, J. M. (1987): “The EMH and CAPM on Nairobi stock Exchange”. *East Africa Economy Review*, vol. 3, no. 2, 105-110.

People’s Daily Online (2005): “Chinese shares close down to eighth years' low”. June 4, 2005. [E-document] [Retrieved July 12, 2006]. From: http://english.people.com.cn/200506/04/eng20050604_188427.html

Pesaran, M. H (2005): “Market Efficiency Today”. *IEPR Working Paper* [E-document] [Retrieved March 23, 2006]. From: http://www.usc.edu/iepr

Poshakwale, S. (1996): “Evidence on Weak Form Efficiency and Day of the Week Effect in the Indian stock Market”. *Finance India*, vol. 10, no. 3, 605-616.

Poterba, J., and Summers, L. (1986): “The Persistence of Volatility and Stock Market Fluctuations”. *American Economic Review*, vol. 76, 1142-1151.

Roberts, H. V. (1959): “Stock market “patterns” and financial analysis: Methodological suggestions”. *Journal of Finance*, vol. 14, 1-10.

Seddighi, H. R., and Nian, W. (2004): “The Chinese stock exchange market: operations and efficiency”. *Applied Financial Economics*, vol. 14, 785-797. Shanghai Securities Market Fact Book 2004.

Shanghai Stock Exchange (SHSE) Fact Book 2004. [E-document] From: http://www.sse.com.cn/en_us/cs/about/factbook/factbook_us2004.pdf

Shanghai Stock Exchange official website: http://www.sse.com.cn/ssportal/en _us/ps/home.shtml.

Sharpe, W. F., Alexander, G. J., and Bailey, J. V. (1999): *Investments*. Sixth Edition. Upper Saddle River: Prentice-Hall, Inc.

Shenzhen Stock Exchange (SZSE) Fact Book 2003. [E-document] From: http://www.szse.cn/main/en/Catalog_1389.aspx

Shenzhen Stock Exchange official website: http://www.szse.cn/main/en

Shirai, S. (2004): “Testing the Three Roles of Equity Markets in Developing Countries: The Case of China”. *World Development*, vol. 32, no. 9, 1467-1486.

Smith, G., and Ryoo, H. J. (2003): “Variance ratio tests of the random walk hypothesis for European emerging stock markets”. *The European Journal of Finance*, vol. 9, 290-300.

Tan, Q. (2004): “State, institution building, and emerging stock markets in China”. *Communist and Post-Communist Studies*, vol. 37, 373-394.

Tas, O., and Dursonoglu, S. (2005): “Testing random walk hypothesis for Istanbul Stock Exchange”. *International Trade and Finance Association Conference Papers.* [E-document] [Retrieved March 23, 2006] From: http://services.bepress.com/otfa/15th/art38

Taylor, S. J. (2005): *Asset Price Dynamics, Volatility, and Prediction.* Princeton: Princeton University Press.

The World Bank Group. (2005): “China at-a-glance”. [E-document] [Retrieved November 26, 2005] From: http://devdata.worldbank.org/AAG/chn_aag.pdf

Timmermann, A., and Granger, C. W. J. (2004): “Efficient market hypothesis and forecasting”. *International Journal of Forecasting*, vol. 20, 15-27.

Urrutia, J. L. (1995): “Tests of random walk and market efficiency”. *Journal of Financial Research*, vol. 18, 299-309.

World Federation of Exchanges official website: http://www.world-exchanges.org

Worthington, A. C., and Higgs, H. (2004): “Random walks and market efficiency in European equity markets”. *Global Journal of Finance and Economics*, vol. 1, no. 1, 59-78.

Yu, T. T., Zhang, M. M., and Qi, S. Z. (2005): “Government Intervention and Market Distortion: The Case of the Chinese Stock Market”. *Journal of American Academy of Business*, vol. 6, no. 2, 32-37.

APPENDICES

Appendix 1: List of the Shanghai Stock Exchange Index Series

Index Name	Launch Day	Base Day	Base Value
Constituent Index			
SSE 180 Index	01/07/2002	28/06/2006	3299.06
SSE 50 Index	02/01/2004	31/12/2003	1000
SSE Dividend Index	04/01/2005	31/12/2004	1000
Composite Index			
SSE Composite Index	15/07/1991	19/12/1990	100
SSE New Composite Index	04/01/2006	30/12/2006	1000
Sector Index			
SSE A Share Index	21/02/1992	19/12/1990	100
SSE B Share Index	17/08/1992	21/02/1992	100
SSE Industrial Index	03/05/1993	30/04/1993	1358.78
SSE Commercial Index	03/05/1993	30/04/1993	1358.78
SSE Real Estate Index	03/05/1993	30/04/1993	1358.78
SSE Utilities Index	03/05/1993	30/04/1993	1358.78
SSE Conglomerates Index	03/05/1993	30/04/1993	1358.78
Other index			
SSE Fund Index	09/06/2000	08/05/2000	1000
SSE T-Bond Index	02/01/2003	31/12/2002	100
SSE Corporate Index	09/06/2003	31/12/2002	100

Source: Shanghai Stock Exchange Fact Book 2004

All SHSE Indices are calculated using a Passche weighted composite price formula:

Reporting Period Index = (Reporting period component stocks' total market value / Base day component stocks' total market value) × base day index

Appendix 2: List of the Shenzhen Stock Exchange Index Series

Index Name	Launch Day	Base Day	Base Value
SSE Component Index	23/01/1995	20/07/1994	1000
SSE Component A Index	23/01/1995	20/07/1994	1000
SSE Component B Index	23/01/1995	20/07/1994	1000
SSE 100 Index	02/01/2003	31/12/2002	1000
SSE New Index	16/02/2006	30/12/2005	1000
SSE SME Composite	01/12/2005	07/06/2005	1000
SSE Composite Index	04/04/1991	03/04/1991	100
SSE A Share Index	04/10//1992	03/04/1991	100
SSE B Share Index	06/10//1992	28/02/1992	100
Agriculture Index	03/04/1991	02/07/2001	1000

Source: Shenzhen Stock Exchange Fact Book 2003

Appendix 3: Performance Indicators of the Shanghai and Shenzhen Stock Exchanges

Performance indicators of the Shanghai and Shenzhen stock exchanges from end of 1996 to end of 2005 are represented. These include a number of listed companies, a market capitalization, a total value of share, a number of trading days and an average daily turnover for both stock exchanges. Market capitalizations, total value of share trading and average daily turnover are denominated in US dollars. The turnover velocity is the ratio between the turnover of domestic shares and market capitalization, and average daily turnover is the total value of share trading divided by the number of trading days during the period. [a] denotes that value of market capitalization is based on end of year 1999, because a market capitalization of year 2000 is not available.

Indicators	1996	1998	2000	2002	2004	2005
Shanghai Stock Exchange						
Number of listed companies	293	496	572	715	837	**833**
Market capitalization (US$ million)	66 012,0	129 805,9	325 354,1	306 443,6	314 315,7	**286 190,3**
Total value of share trading	333 343,0	156 923,0	395 148,7	211 243,9	322 828,6	**238 520,8**
Turnover velocity (%)	-	-	-	-	87,0	**82,1**
Number of trading days	244	246	239	237	243	**242**
Average daily turnover (US$ million)	-	-	-	893,0	1348,5	**985,6**
Shenzhen Stock Exchange						
Number of listed companies	237	413	514	508	536	**544**
Market capitalization (US$ million)	52 596,6	107 257,2	143 607,7[a]	156 647,6	133 404,6	**115 661,9**
Total value of share trading	170 580,6	139 750,0	373 552,7	140 660,6	194 457,7	**154 251,6**
Turnover velocity (%)	-	-	-	-	120,5	**128,9**
Number of trading days	244	246	239	237	243	**242**
Average daily turnover (US$ million)	-	-	-	593,5	800,2	**637,4**

Source: World Federation of Exchanges
(Note: Turnover velocity of both exchanges between 1996 and 2002, and average daily turnover of both stock exchanges between 1996 and 2000 are not available)

Appendix 4: Chinese Stock Market Compared with Emerging Stock Markets and Developed Markets

Performance statistics for emerging stock markets and developed markets in the end of year 1998 are presented. These include a number of listed companies, a market capitalization, trading value and turnover ratio for each country. Market capitalization and trading value are denominated in US dollars. Turnover ratio is the total value traded divided by average market capitalization.

Country	No. of listed companies	Market capitalization (US$ million)	Trading value (US$ million)	Turnover ratio (%)
Emerging markets				
Argentina	136	45,332	15,078	28.8
Brazil	527	160,887	146,594	70.4
China	**853**	**231,322**	**284,766**	**130.1**
Greece	244	79,992	46,999	82.3
India	5860	105,118	64,498	55.2
Korea	748	114,593	137,859	176.2
Malaysia	736	98,557	28,835	30.0
Mexico	197	91,746	33,841	27.3
Philippines	221	35,314	9,992	30.0
Saudi Arabia	74	42,563	13,712	26.9
South Africa	668	170,252	58,443	82.3
Taiwan	437	260,015	884,698	323.0
Thailand	418	34,903	20,734	71.0
Turkey	277	33,646	68,646	144.9
Developed markets				
Germany	741	1,093,962	1,390,798	144.9
Hong Kong	658	343,394	205,918	54.4
Japan	2416	2,495,757	948,522	40.3
Singapore	321	94,469	50,735	50.5
UK	2399	2,374,273	1,167,382	53.4
U.S.	8450	13,451,352	13,148,480	106.2

Source: International Financial Corporation's (IFC) Emerging Stock markets Fact Book 1999

Appendix 5: Autocorrelation Coefficients

Table presents first to fifteenth-order autocorrelation coefficients for the full sample period 1992 to 2005 and three sup-periods. These autocorrelation coefficients are used to calculate variance ratios. SHSE-A, SHSE-B and SHSE-C refers to Shanghai A-share, B-share and Composite indices, respectively. SZSE-A, SZSE-B and SZSE-C refers to Shenzhen A-share, B-share and Composite indices, respectively.

Full period	SHSE-A	SHSE-B	SHSE-C	SZSE-A	SZSE-B	SZSE-C
Lags						
1	0.044	0.162	0.044	0.013	0.149	0.029
2	0.042	0.006	0.042	0.034	0.033	0.028
3	0.046	0.044	0.043	0.024	0.089	0.028
4	0.031	0.018	0.028	0.071	0.082	0.086
5	0.028	0.003	0.023	0.012	0.021	0.013
6	-0.021	0.013	-0.021	-0.053	0.019	-0.045
7	-0.010	-0.003	-0.010	-0.011	0.032	-0.003
8	-0.022	0.011	-0.020	-0.010	0.045	-0.012
9	0.029	0.015	0.027	0.002	0.005	0.021
10	-0.016	0.035	-0.017	-0.036	0.032	-0.028
11	-0.055	0.025	-0.051	-0.001	0.003	-0.008
12	0.035	0.029	0.036	0.038	0.022	0.051
13	-0.012	0.008	-0.011	-0.011	0.013	-0.004
14	0.030	0.007	0.032	0.039	0.017	0.035
15	0.015	-0.000	0.016	0.020	-0.006	0.024
1992-1995	**SHSE-A**	**SHSE-B**	**SHSE-C**	**SZSE-A**	**SZSE-B**	**SZSE-C**
1	0.060	0.276	0.061	0.007	0.285	0.034
2	0.057	0.056	0.059	0.043	0.177	0.036
3	0.038	0.032	0.034	-0.029	0.088	-0.014
4	0.038	0.015	0.034	0.101	0.139	0.117
5	0.037	0.035	0.032	0.018	0.064	0.033
6	-0.021	0.021	-0.022	-0.080	0.042	-0.071
7	-0.003	0.064	-0.003	-0.015	0.039	0.003
8	-0.021	-0.004	-0.020	-0.007	0.036	0.027
9	0.056	0.029	0.056	0.044	0.018	0.071
10	-0.021	0.042	-0.023	-0.080	0.043	-0.061
11	-0.061	0.068	-0.056	-0.011	0.057	-0.007
12	0.030	0.036	0.032	0.028	0.027	0.047
13	-0.007	0.043	-0.006	0.002	0.007	0.008
14	0.035	-0.003	0.038	0.029	0.016	0.034
15	-0.011	0.010	-0.011	-0.023	0.055	-0.017
1996-2000	**SHSE-A**	**SHSE-B**	**SHSE-C**	**SZSE-A**	**SZSE-B**	**SZSE-C**
1	-0.019	0.157	-0.016	0.010	0.149	0.015
2	-0.004	-0.018	-0.004	0.036	0.019	0.031
3	0.095	0.060	0.094	0.105	0.076	0.101
4	0.011	0.007	0.013	0.042	0.055	0.061
5	0.015	-0.023	0.013	0.009	0.017	-0.015
6	-0.028	-0.015	-0.026	-0.034	-0.030	-0.022
7	-0.067	-0.034	-0.067	-0.028	-0.006	-0.032
8	-0.040	0.000	-0.040	-0.029	0.058	-0.022
9	-0.069	0.021	-0.069	-0.060	-0.002	-0.045
10	-0.006	0.021	-0.008	0.012	-0.009	0.011
11	-0.057	0.006	-0.055	0.005	-0.023	-0.023
12	0.059	0.028	0.059	0.056	0.002	0.068
13	-0.035	-0.002	-0.036	-0.036	-0.004	-0.026
14	0.005	-0.005	0.005	0.056	0.009	0.038
15	0.139	0.013	0.138	0.103	-0.002	0.113

Table (continued)

2001-2005	SHSE-A	SHSE-B	SHSE-C	SZSE-A	SZSE-B	SZSE-C
Lags						
1	0.011	0.086	0.010	0.030	0.107	0.027
2	-0.027	0.008	-0.026	-0.021	0.013	-0.021
3	0.014	0.026	0.012	0.026	0.111	0.026
4	0.002	0.037	0.006	0.002	0.111	0.004
5	-0.040	0.018	-0.039	-0.023	0.011	-0.022
6	-0.012	0.055	-0.009	-0.006	0.093	-0.003
7	0.034	0.005	0.031	0.029	0.094	0.029
8	0.012	0.036	0.014	0.015	0.024	0.015
9	-0.043	-0.011	-0.046	-0.044	0.010	-0.046
10	0.012	0.055	0.013	0.013	0.096	0.013
11	-0.006	0.024	-0.002	0.005	0.028	0.007
12	0.019	0.029	0.019	0.019	0.057	0.019
13	-0.011	-0.002	-0.008	-0.021	0.041	-0.017
14	0.016	0.033	0.013	0.022	0.028	0.018
15	-0.002	-0.032	-0.001	-0.018	-0.035	-0.018