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Securities trading in multiple markets: the Chinese perspective

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By

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DECLARATION

In accordance with the Regulations for Higher Degrees by Research, I hereby declare that the whole thesis now submitted for the candidature of Doctor of Philosophy is a result of my own research and independent work except where reference is made to published literature. I also hereby certify that the work embodied in this thesis has not already been submitted in any substance for any degree and is not being concurrently submitted in candidature for any degree from any other institute of higher learning. I am responsible for any errors and omissions present in the thesis.

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Chaoyan Wang

Abstract

This thesis studies the trading of the Chinese American Depositories Receipts (ADRs) and their respective underlying H shares issued in Hong Kong. The primary intention of this work is to investigate the arbitrage opportunity between the Chinese ADRs and their underlying H shares. This intention is motivated by the market observation that hedge funds are often in the top 10 shareholders of these Chinese ADRs. We start our study from the origin place of the Chinese ADRs, China's stock market. We pay particular attention to the ownership structure of the Chinese listed firms, because part of the Chinese ADRs also listed A shares (exclusively owned by the Chinese citizens) in Shanghai. We also pay attention to the market microstructures and trading costs of the three China-related stock exchanges. We then proceed to empirical study on the Chinese ADRs arbitrage possibility by comparing the return distribution of two securities; we find these two securities are different in their return distributions, and which is due to the inequality in the higher moments, such as skewness, and kurtosis. Based on the law of one price and the weak-form efficient markets, the prices of identical securities that are traded in different markets should be similar, as any deviation in their prices will be arbitraged away. Given the intrinsic property of the ADRs that a convenient transferable mechanism exists between the ADRs and their underlying shares which makes arbitrage easy; the different return distributions of the ADRs and the underlying shares address the question that if arbitrage is costly that the equilibrium price of the security achieved in each market is affected mainly by its local market where the Chinese ADRs/the underlying Hong Kong shares are traded, such as the demand for and the supply of the stock in each market, the different market microstructures and market mechanisms which

produce different trading costs in each market, and different noise trading arose from asymmetric information across multi-markets. And because of these trading costs, noise trading risk, and liquidity risk, the arbitrage opportunity between the two markets would not be exploited promptly. This concern then leads to the second intention of this work that how noise trading and trading cost comes into playing the role of determining asset prices, which makes us to empirically investigate the comovement effect, as well as liquidity risk. With regards to these issues, we progress into two strands, firstly, we test the relationship between the price differentials of the Chinese ADRs and the market return of the US and Hong Kong market. This test is to examine the comovement effect which is caused by asynchronous noise trading. We find the US market impact dominant over Hong Kong market impact, though both markets display significant impact on the ADRs' price differentials. Secondly, we analyze the liquidity effect on the Chinese ADRs and their underlying Hong Kong shares by using two proxies to measure illiquidity cost and liquidity risk. We find significant positive relation between return and trading volume which is used to capture liquidity risk. This finding leads to a deeper study on the relationship between trading volume and return volatility from market microstructure perspective. In order to verify a proper model to describe return volatility, we carry out test to examine the heteroscedasticity condition, and proceed to use two asymmetric GARCH models to capture leverage effect. We find the Chinese ADRs and their underlying Hong Kong shares have different patterns in the leverage effect as modeled by these two asymmetric GARCH models, and this finding from another angle explains why these two securities are unequal in the higher moments of their return distribution. We then test two opposite hypotheses about volume-volatility relation. The Mixture of

Distributions Hypothesis suggests a positive relation between contemporaneous volume and volatility, while the Sequential Information Arrival Hypothesis indicates a causality relationship between lead-lag volume and volatility. We find supportive evidence for the Sequential Information Arrival Hypothesis but not for the Mixture of Distributions Hypothesis.

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List of Abbreviations

AMS	Automatic Order Matching and Execution System
CSDCC	China Securities Depository and Clearing Corporation Ltd
CSRC	China Securities Regulatory Commission
GAAP	Generally Accepted Accounting Principles
HKSAR	Hong Kong has been a special administrative region of China
HKSCC	Hong Kong Securities Clearing Co Ltd
IAS	International Accounting Standards
IFC	International Finance Corporation
IPO	Initial Public Offering
LP	Legal Person
M&A	Mergers & Acquisition
MBO	Management Buy-Out
MDH	Mixture of Distributions Hypothesis
NAV	Net Asset Value
OTC	Over-The-Counter
PBOC	People's Bank of China
QDII	Qualified Domestic Institutional Investors
QFII	Qualified Foreign Institutional Investor
RMB	Renminbi
SASAC	State-owned Assets Supervision and Administration Commission of the State Council
SEC	Securities and Exchange Commission
SEHK	Stock Exchange of Hong Kong
SIAH	Sequential Information Arrival Hypothesis
SHSE	Shanghai Stock Exchange
SOEs	State Owned Enterprises
SZSE	Shenzhen Stock Exchange

Chapter 1

Introduction

What determines asset prices? The standard theory in financial economics, the Efficient Market Hypothesis (EMH), argues prices are always consistent with the 'fundamentals'; and equilibrium prices are passively achieved by the market, because an efficient market should 'fully reflect all available information' (Fama, 1991). This implies that the market processes information rationally, in the sense that relevant information is not ignored, and systematic errors are not made.

Based on the EMH, in the classic asset pricing theory, the fundamental value of an asset is measured by the delay or the risk of payoff, if an asset is over-priced (under-priced), which implies a low (high) rate of return. So, return accounts for compensation for the risk of *holding* an asset.

However, one question arose when scholars attempted to shed some lights on how securities are traded in the market, that is whether the equilibrium price consistent with the 'fundamentals' would be achieved by the market? Demsetz (1968) suggested that trade may involve some cost, which could be explicit or implicit. And he referred to the implicit cost as the costs connected with *immediate* execution of trading. Trading in stock markets can sometimes be frictional in the sense that supply and demand may fail to match. Under such circumstances somebody, most probably the market makers, have to offer liquidity for '*immediate* execution of trading' to take place. The market makers who supply this liquidity must be compensated for the risk they have taken by trading an asset *immediately* before its equilibrium price has been established. So, return, in this sense, also accounts for compensation for the risk of *trading* an asset. Amihud and Mendelson (1986) carried out an empirical study of trading cost and found a direct link between securities return and liquidity measured by their bid-ask spread. Since then, the empirical relationships between return and liquidity have been well documented.

The purpose of this thesis is to consider a particular setting where an identical security (e.g. American Depository Receipt (ADR)) is traded in multiple markets, and to study why an ADR and its identical underlying share are not guaranteed to be traded at the same price in host and home markets. An American Depository Receipt (ADR) represents the ownership in the shares of a foreign company trading on the US financial markets and subjected to commission fees, an ADR is possible to be converted into its underlying shares or *vice verse*. ADR and its underlying share are in principle identical security, however in practice these are somehow traded at different prices across markets.

In this thesis, we aim to answer these following questions. First of all, we consider the question whether or not the Law of One Price exists (the Law hereafter). The Law states that if two assets have the same payoffs (in every state of nature), then given the weak form of efficient markets, they must trade at the same price. And the Law relates to the impact of market arbitrage on the prices of identical assets exchanged in two or more markets. A deviation from this Law would give rise to an arbitrage opportunity, as long as the price differential exceeds all related transaction costs. However, in practice, the arbitrage activity across multi-markets is subject to the market segmentation. When two markets are segmented with each other by imposing different tax rate, having restrictions on foreign ownership and currency, and employing asynchronous trading hours, the arbitrageurs have difficulties to promptly remove price differentials. So the investigation of the Law in multiple markets would address additional questions related with international financial markets segmentation.

Therefore, integration vs. segmentation is the next concern for this study, because the linkage between the markets will affect capital flow and information transmission, and in turn, the arbitrage opportunity. A segmented market is defined in finance as a market where free labor, capital and information flows are restricted, for example, foreign currency controls and foreign ownership limits. In addition, in cross market trading, a segmented market also refers to a market with little or no overlapping trading hours with its counterpart. Usually, more trades are executed during the overlapping trading hours; as a result, a lower liquidity premium and higher volatility are observed in both markets.

Third, we consider the question what is the market liquidity effect in multiple market trading. It is clear how liquidity as a cost is priced in a single market, yet how the liquidity effect varies across markets is still unclear. The explanations may come from different trading mechanisms and market microstructures which provide different liquidity risks and transaction costs, as well as from different price stabilization policies which affect volatilities.

Finally, a better understanding on the relation between return volatility and trading volume in dual markets trading is helpful in exploring how information flow affects trading differently across markets. ‘Exchange occurs when market agents assign different values to an asset’ (Karpoff, 1986). Trading volume therefore is viewed as a variable which contains trading information, and traders in turn would revise their demand prices based on the observed trading volume data. As a result, return volatility is higher when trading is more active.

The Chinese American Depository Receipts offer a unique opportunity to investigate all the questions mentioned above. In addition, their distinctive characteristic makes this study an important contribution to the literature of the ADRs. Unlike the ADRs from other developed and emerging countries which are usually in the framework of two related markets, the Chinese ADRs involve three related markets due to the fact that a part of these Chinese firms listed A shares (exclusively owned and traded by the Chinese citizens in mainland China) in Shanghai after they sequentially listed ADRs in the US and H shares in Hong Kong (the ADRs and H shares are exclusively owned and traded by foreign investors). The A shares listing makes China's domestic stock market as one of important factors when we investigate the market segmentation. And two additional interesting concerns arose, first, A shares listings would increase shareholders base of these listed firms, and leads to the decrease in the returns of the ADRs and H shares. This suspect is based on the 'Investors' Recognition Hypothesis' by Merton (1987), who argued that expected return of the firm's stock decrease with the size of the investor's shareholder base. Second, we suspect that for the Chinese ADRs with A shares listed in Shanghai, the price differentials between the Chinese ADRs and the underlying H shares will be affected by China's domestic stock market as well, because of the close geopolitical relation between China and Hong Kong in terms of overlapping trading hours, common culture and business activities.

Apart from the special characteristic we have mentioned above, we notice that the NYSE listed Chinese ADRs are exclusively state owned enterprises (SOEs), while those listed in the NASDAQ are all private firms. This obvious difference in cross-listing locations suggests that the ownership structure of these Chinese firms may contribute to understand the price behaviour of these Chinese ADRs. Further, the SOEs listed in the NYSE are enterprises with monopoly power in some important industries, such as utility, electronic communication, and oil and gas. Then one more question arose that why the Chinese government want to list these important companies abroad. Since the conventional perspective is the Chinese government would like to entirely control the SOEs.

We therefore start our research from the origin place of the Chinese ADRs: China's domestic stock market. Chapter 2 provides an outline and analysis of China's stock market liberalization and the market microstructures of the two domestic stock exchanges in China and the stock exchange in Hong Kong. There are two reasons why we present this survey of the domestic China's stock market before we proceed to the empirical research on the Chinese ADRs' arbitrage. First, as we have mentioned before, part of the Chinese ADRs have additional A shares listed in Shanghai, which takes the impact from China's stock market into account. Second, the Chinese ADRs include both SOEs and private firms, and these two types of firms have extremely different listing patterns and listing locations, which inspires us to take a deeper examination on the ownership structure of the Chinese listed firms.

We will focus on the special characteristics of the Chinese listed firms, investors, and stock exchange which are normally the three components of a stock market. China's stock market makes itself unique by imposing restrictions on state-owned and non-state-owned shares of the listed firms; state-owned shares are non-tradable while non-state-owned shares are tradable. Further, the investors of the tradable shares are divided into domestic citizens and foreigners. Domestic investors can only own A shares, while foreign investors can either own H shares (listed in Hong Kong) or B shares (listed in mainland China). We will discuss the different types of shares and segmented sub-markets in detail in chapter 2, and focus on the impact of these restrictions on the performance of the listed firms and the function of the markets. Some interesting issues are investigated, such as two-thirds non-tradable state-owned shares, and the price discount puzzle. However, since China joined the WTO in 2002, China's domestic capital market has been gradually opened up to foreign investors, as well as relaxing controls on domestic citizens diversifying their portfolios by investing abroad. We will also give detailed introduction on these market innovations.

Chapter 2 also examines the market microstructure and transaction costs of the three China-related stock exchanges: the Shanghai stock exchange, the Shenzhen stock exchange, and the stock exchange of Hong Kong. We provide an overview of the market condition of each market, such as market capitalization, the ratio of market capitalization to GDP, P/E ratio, annual trading value, and annual turnover trading value. In particular, for China's stock market we also look at the market capitalization of the tradable shares which turns out to be extremely small, while the ratio of the total trading value to the market capitalization of the tradable shares is extremely high. A comparison of market mechanisms is also provided, which includes the dealer mechanism vs. the auction mechanism; floor based trading vs. automated trading; clearing and settlement system; and market maker system. We also report the market regulations to control market volatility, and compare the explicit and implicit transaction costs.

Chapter 3 presents the reviews of the ADRs' literature and the studies of liquidity.

We categorize the existing papers about ADRs into three issues, namely, firms' motivation for cross-listing, price discovery, and the ADRs' arbitrage. The first issue is from the viewpoint of firms which explains the benefit of listing shares in overseas markets, especially for the firms from emerging markets to cross-list in developed markets. The second issue, price discovery, is from the viewpoint of market. Price discovery is defined as the search for an equilibrium price and is a central function of a stock exchange. For the ADRs, the research question is in which market that price discovery takes place, the host or home market? And two relevant hypotheses will be addressed, segmented market hypothesis and the cost of capital. The third issue, the ADRs' arbitrage, is from the viewpoint of traders, the trading strategies of informed traders and noise traders. In particular, we will review the papers with regard to two questions. First, does the arbitrage possibility exist? Second, why arbitrageurs do not exploit the price differentials of the ADRs? In this chapter, we also review the papers about liquidity effect on asset pricing. We focus on the different measures of liquidity, and emphasize to be aware of the different concept between liquidity level and liquidity risk.

Chapter 4 contains empirical studies on the Chinese ADRs' arbitrage. We follow the literature review in chapter 3 to develop our test hypotheses. We answer the first question that whether the Law exists between the Chinese ADRs and their underlying H shares. Since the findings about the existing of the arbitrage possibility in the ADRs are inconsistent, and we believe the different findings are due to different approaches that used in those papers. We then apply the approaches of the papers which claim no arbitrage possibility is found, as well as the approaches of the papers which find that the arbitrage possibility may exist due to the different return distributions between the ADRs and their underlying shares. Our findings indicate that although we can not reject the Law existing in the Chinese ADRs by comparing mean and median of the two securities' returns, we still find return distributions are different between the Chinese ADRs and their underlying H shares, especially different in the tails. In addition, we find that the Chinese ADRs with A shares listed in Shanghai are different with those without A shares in terms of distributions of return and return spread.

We then proceed to answer the second question why the arbitrage activity is hampered by examining two effects, the comovement effect and liquidity effect. The comovement effect is caused by the information based barriers between two segmented markets due to asynchronous noise trading in two markets. The professional arbitrageurs who are usually subject to short term horizon face the risk to bet against the asynchronous noise traders. The comovement effect suggests that with regard to the dual-listed shares, the stock's return will move with its local market return rather than with the off-shore market return. We find significant evidence for the contemporaneous and lagged comovement effect on the Chinese ADRs and their underlying H shares.

Further, we examine the liquidity effect which is caused by trade based barriers between two segmented markets. The liquidity effect suggests that different illiquidity costs between the host and home market may increase the risk for the arbitrageurs to exploit arbitrage profit. Chapter 2 has discussed the market microstructure and compared trading costs of the Hong Kong stock exchange and two stock exchanges in mainland China, where applicable, we also compare the trading costs with those of the two US stock exchanges. The difference in the market microstructure leads to different illiquidity and liquidity risk. Therefore, we employ two proxies to measure illiquidity and liquidity risk respectively, and provide evidence for the liquidity effect.

Finally, we conduct a sub-period test to find out whether or not market liberalization in China and market collapse in the US have any impact on ADRs' return spread. Two breaking points are selected, the years 2000 and 2003, the significant structural changes are found around 2000, and a time-varying market impact from China and Hong Kong market index is reported.

Chapter 5 is to study the volume-volatility relation of the Chinese ADRs and their underlying shares. This chapter is an extension of the study on liquidity risk in chapter 4. As the literature suggests that trading volume may contain trading information, and return volatility increases when new information arrives at the market. The process that traders keep adjusting their expected prices upon new information arrival is viewed as an implication of volume-volatility relation. We first find a proper approach to model return volatility, and then compare the volume-volatility relation of the Chinese ADRs and that of their underlying H shares. Our findings not only justify the use of two General Autoregressive Conditional Heteroskedastic (GARCH) models, but also provide evidence that the US and Hong Kong investors respond to the bad news differently, and this difference in the investors' sensations may explain the different return distributions of two securities as we show in chapter 4. Our findings also provide evidence of the validity of two competing theories in the volume-volatility relation; the Mixture of Distributions Hypothesis (MDH) is not verified by our results, while the Sequential Information Arrival Hypothesis (SIAH) is supported.

Finally, in chapter 6, we provide the conclusion of the new findings and limitations of this thesis.

This study makes important contribution to the literature in several areas. First, in chapter 2, we give a completed systematic investigation on the three China-related stock markets with respect to trading mechanisms, market microstructure, transaction costs, and volatility control policies, to our best knowledge, no published papers on this area have involved all these three markets, and all data and information we provide in this thesis are up-to-date, which is by the end of 2006.

Second, in chapter 4, we point out that the standard location tests, such as t-test and Wilcoxon ranked test, are not enough to convince that no arbitrage possibility exists in the ADRs. For the cross-listed securities, the difference in return distributions may provide arbitrage possibility even though these two securities are equal in the mean of their returns.

We make complement to the literature of the comovement effect on the ADRs' arbitrage that not only the contemporaneous but also the lagged market return has impact on the securities traded in there. We also provide supportive evidence to the argument by Kim et al (2000) that the US investors are over-reacting the US market shocks, since we have showed that the lagged market impact from the US is significantly negative.

Further, we find obvious difference in the Chinese ADRs without A shares and those with A shares. The average returns of the ADRs without A shares are higher than those with A shares, this finding justify the 'Investor's Recognition Hypothesis' that the increase in the shareholders base will decrease expected return of the stocks. In addition, we find the magnitude of the comovement effect of the Chinese ADRs without A shares is bigger than those with A shares. This may suggest that the Chinese ADRs without A shares move more closely with the local market than those with A shares.

Third, in chapter 5, we employ two GARCH models to examine leverage effect, which reflects investors' sensation to good news and bad news. We not only make contributes to the literature of the ADRs arbitrage that different return distributions between the ADRs and underlying shares could be caused by heterogeneous investors' sensation to bad news. We also give supportive evidence for the recently developed hypothesis of 'Investors Sentiment' in behaviour finance, which suggests stock price is a function of investors' sentiment.

Chapter 2

A Survey of China's Stock Market

2.1 Introduction

China's experience with its securities markets extends back to 1891 when foreign brokers founded the 'Shanghai Sharebrokers' Association', which was headquartered in Shanghai as China's first stock exchange. In 1904 the Association applied for registration in Hong Kong and it was renamed as the 'Shanghai Stock Exchange'. By the 1930s, Shanghai had emerged as the financial centre of the Far East, where both the Chinese and foreign investors could trade stocks, debentures, government bonds, and futures; the Shanghai Stock Exchange grew to be the largest domestic securities exchange with 140 listed companies. The operation of Shanghai Stock Exchange paused in 1941 because of the World War II, and re-opened in 1946, but closed again since 1949 when the Communist revolution took place (Lavelle, 2004).

The milestone in the development of China's stock market is the establishment of the Shanghai Stock Exchange and the Shenzhen Stock Exchange in the early 1990s, before that, the Chinese government had done some experiments in Shanghai and Shenzhen by setting up Over-The-Counter (OTC) markets where only small-scale trading of treasury securities and shares were processed, and the security prices on the OTC markets were determined by negotiation between buyers and sellers, instead of on the basis of auction. By the end of 2006, there were a total of 1434 listed firms, and the total market capitalization is RMB 8,940.4 billion (US$ 1146.2 billion) in both stock exchanges, and among them, Shanghai Stock Exchange accounts for RMB 7,161.9 billion

(US$ 873.0 billion).

A large number of books, research papers and reports about China's stock market have given us valuable insights into the development and working of China's stock market. Green (2003) and Walter and Howie (2003) have provided a detailed coverage of the history of China's equity market and state owned enterprises (SOEs) reform from mid 1980s to early 2000s, right before the ownership structure reformation of China's stock market.

In this survey paper, we try to present a picture of the uniqueness of the Chinese stock market through investigating the three components of the market. Stock exchange, listed firms, and the shareholders are the three necessary components which make up a conventional stock market and this is also the case for China's stock market. However, almost each of these three components has unparalleled features in China which makes the Chinese market unique.

In section 2.2, we start by looking at the listed firms with focusing on their ownership and shareholder structure. China is a country without any history or tradition of private property rights since 1949, and, therefore, is experiencing a process of ongoing transition from a highly centrally planned economy to a market economy at present; and in addition, a country which is more or less still governed according to the socialist ideology inherited from the Maoist period. In China's stock market, the listed companies issue two-thirds non-tradable shares which are controlled by the state and the investors have a limited choice to decide the type of shares they can buy, even though the stock exchanges have adopted one of the most advanced electronic trading systems in the world.

The Chinese listed firms differ from the listed firms in other developed or emerging stock markets not because they are state owned enterprises (SOEs) but because around two-thirds of non-tradable shares issued by the listed firms are ultimately controlled by the state, while only the one-third of shares can be traded in the stock market. Although the Chinese authorities arranged to make one-third of shareholdings of the listed SOEs available to private investors, this partial privatization without changing the listed firms' control rights has been found to be the main reason behind the failure in improving the performance and corporate governance of the listed SOEs in the literature (Groves et al., (1994); Gao, (1996); Cao et al., (1999); Allen et al., (2005)).

The two-thirds ownership of non-tradable shares by the state has not only hindered the performance of the Chinese listed SOEs but has also become a critical blockage to a healthy progress of China's stock market. It has also brought a number of other problems; from the early 2000s, the Chinese authorities have made several attempts to deal with the problem of non-tradable shares on several occasions. However, all these attempts ended up in failures, until April 29, 2005, when the China Securities Regulatory Commission (CSRC) announced a new pilot program, inviting a first batch of four state owned companies to transform their non-tradable shares into tradable shares by compensating the existing shareholders in various ways like bonus shares, cash, and options. The main difference of this policy from the previous attempts is that the new reform allowed the tradable shareholders to bargain over the transfer of non-tradable shares. Such flexibility seemed to be working well. Among these four companies, only one firm failed. On June 2005, the CSRC initiated the second pilot program involving 42 companies worth 10% of overall stock market value. On August 19 2005, this second program was successfully accomplished. We leave the detailed discussion about the listed companies' ownership structure and the reformation in section 2.2.

In section 2.3, we shed lights on the segmented nature of the stock market with regards to shareholders, which includes three sub-markets, A share market for domestic shareholders, B and H share market for foreign shareholders. The problem along with the segmented market is price puzzle, for example, the investors in one sub-market have to pay higher (lower) prices than the investors in other sub-markets, and this raises the question: what is the true value of a listed firm? Most researches reveal that this price puzzle is due to the artificial barriers set up by the Chinese authority.

However, China's stock market has been making progress step-by-step to break down the barriers. On February 19, 2001; the China Securities Regulatory Commission (CSRC) announced that the Chinese residents would be allowed to own B shares, which are shares of mainland companies and traded in both the Shanghai and Shenzhen stock exchanges and denominated in US$ (Shanghai stock exchange) and HK$ (Shenzhen stock exchange). Further, on November 5, 2002 the CSRC and the People's Bank of China (PBOC) introduced the QFII (Qualified Foreign Institutional Investor) program as a provision for foreign capital to access China's financial markets. On 13 April 2006 the Chinese authorities launched QDII (Qualified Domestic Institutional Investors), a scheme under which selected government authorized domestic institutional investors are allowed to invest in overseas capital markets under the foreign exchange control system in China. However, till now this facility is restricted to investment in the capital market of Hong Kong only (Neftici et al., 2007; information can be also found in the official website: http://www.csrc.gov.cn).

These policies have partially released ‘price discount puzzle’, for example, part of B share discount declined after February 19, 2001, on the other hand, QFII and QDII are with limited application by institutional investors, a thorough integration of three sub-markets, as yet, remains incomplete.

In section 2.4, we look at the stock exchanges by focusing on the market microstructure, and compare it with the Hong Kong stock exchange where H shares are traded. We provide an overview of the market condition of each market, such as market capitalization, the ratio of market capitalization to GDP, P/E ratio, annual trading value, and annual turnover trading value. Particularly, for China’s stock market we also look at the market capitalization of the tradable shares which turns out to be extremely small, while the ratio of the total trading value to the market capitalization of the tradable shares is extremely high. We compare the different market mechanisms, which include dealer mechanism vs. auction mechanism; floor based trading vs. automated trading; clearing and settlement system; and market maker system. We also report the market regulations to control market volatility, and transaction costs.

2.2 The Chinese Listed Companies, Impact of Ownership Structure on China’s Stock Market

2.2.1 A Brief History of China’s Stock market

Beginning in the late 1980s, enterprise reforms took place during China’s gradual transition to a market economy; many SOEs and collective enterprises issued shares to their employees in order to save on wage expenses. Local governments in China started experimenting with selling shares of collectively owned enterprises directly to private individuals in order to raise equity capital. Private property rights, as well as the term 'property rights', was reintroduced in the sphere of share holdings by law for the first time since its abolition in China in 1949, when the Chinese Communist Party introduced socialism in China. However, still in the spirit of the socialist ideology and centrally planned economy, the policies were designed to improve the performance of state owned firms rather than outright transfer of their ownership to the private sector. Two over-the-counter (OTC) markets were launched; one was in Shanghai in 1984 and the other was in Shenzhen in 1986, there were only a handful of shares trading in these informal exchanges.

Nevertheless, funding raised in this way proved to be vastly insufficient for the SOEs in their process of transferring from a planned to a market based institutions, so in the late 1990s and early 1991s, two stock exchanges, created respectively by the Shanghai municipal government and the Shenzhen municipal government, were established, with the central government's formal approval.

Table 2.1 Chronology of the historical events of the China's stock market

1891	Shanghai Stock Exchange founded to broker foreign stocks
1905	Shanghai People's Exchange founded in Hong Kong
1914	Shanghai Stock Commercial Association founded: China's first formal stock trading association; Northern Government issues "Stock Exchange Law"
December 1,1990	Shenzhen begins "trial operations" without formal approval and with only one stock trading
December 19,1990	Shanghai Stock Exchange begins operations. PBOC announces that all public stock issues and listings can only be done on the Shanghai and Shenzhen exchanges: opens the primary market again
July 3, 1991	Shenzhen Stock Exchange is formally approved and opened after seven months of "trial operation"

October 7, 1992	Brilliance China Automotive lists on the NYSE, raising US$80 million. This was China's first ever overseas IPO
October 25, 1992	CSRC established; shortly after announces nine candidates companies for Hong Kong listing, known as the "First Batch"
July 29, 1993	Tsingdao Beer completes the first SEHK IPO by a Chinese company, raising US$115 million
December 29, 1993	National People's Congress passes the Company Law
July 1, 1994	Zhu Rongji signs Company Law into effect permitting Shandong Huaneng (HNP later) to proceed with its NYSE listing, the first direct listing of a Chinese company on the NYSE
August 10, 1994	First direct listing of a Chinese company on the NYSE, Shandong Huaneng Power Generation, raising US$333 million
July 1, 1997	Hong Kong returns to Chinese sovereignty
December 29, 1997	National People's Congress at last passes Securities Law
July 1, 1999	Securities Law goes into effect; CSRC begins preparing regional offices that would give it a national presence for first time
October 27, 1999	Sale of state shares through inclusion in public offerings announced
March 14, 2000	The CSRC approves listing and trading of leftover rights offering shares (zhuanpeigu) beginning in April. A start to getting rid of residual "non-tradable" shares
March 17, 2000	To comply with the Securities Law, CSRC releases regulations defining the new review method (*hezhunzhi*) for listing applications, and eliminates old quota and administrative pricing mechanisms
February 19, 2001	Domestic investors permitted to buy B shares
November 5, 2002	The CSRC and the People's Bank of China (PBOC) introduced the QFII (Qualified Foreign Institutional Investor) program as a provision for foreign capital to access China's financial markets.
April 13, 2006	The CSRC and the People's Bank of China (PBOC) introduced the QDII (Qualified Domestic Institutional Investors), which allows selected government authorized domestic institutional investors to invest in overseas capital markets under the foreign exchange control system in China.

Source: *Walter and Howie, 2003*

2.2.2 The Features of China's Stock market

China's stock market remains a hybrid with planned and market-oriented components; since its initiation, it has formulated particular rules which are clearly different from those of the conventional stock markets. Normally, a stock market consists of the stock exchange, listed firms and shareholders, and the foundation of this framework is an entity of private property with legal protection. It is difficult to imagine that in a country such as China with a fairly short experience of private ownership, securities and stock exchanges could truly exist and function as well as the established conventional stock exchanges. On the other hand, while the critical role that a stock market is supposed to play is to mobilize and allocate capital resource in a market economy; the primary motivation for developing China's stock market was to mobilize private funds in order to finance SOEs as well as to improve SOEs performance through public participation. An efficient stock market should possess the ability to allocate capital into the most productive sectors as soon as possible; in contrast, China's stock market apparently favours SOEs alone without any considerations of their performance.

Incorporation and listing of a minority of stakes of SOEs through IPOs is not an activity which is unique to China. Berkman, et al. (2002) showed that the median offering of IPOs was only 35% of a firm's equity capital based on a worldwide sample of 384 SOEs' share-issue during 1977-1997. But, China is rather unique in creating such a rigid set of share types, placing restrictions on the trading and ownership of each.

In most developed or emerging stock markets, the common shares issued by companies give specific rights to their owners, primarily the right to vote at shareholders' meetings, to receive companies' profits in the form of dividends and to sell the shares in the secondary market if the owner so wishes. All owners of common shares enjoy these rights and are treated equally under most circumstances.

In contrast, although China has artificially created three categories of individual, legal person and state shares and awarded all of them exactly the equal rights by law, legal person and state shares which accounted for around two-thirds of the total outstanding shares of listed firms were declared non-tradable. However, as we will see later, following the reform, which started in 2005, this situation has changed considerably.

Individual shares, in China, are the only sort of shares that can be listed and publicly traded on the stock exchanges, owned by retail investors or employees of a company who have invested their own wealth in the company.

State shares are issued to authorized government organs acting on behalf of the state in return injection of assets such as buildings, equipments, and land-use rights. State shares are owned ultimately by the State Council and are currently managed by the State-owned Assets Supervision and Administration Commission of the State Council (SASAC) and local state asset management bureaux.

Legal Person (LP) shares are created through the injection of assets from legal person entities, which include enterprises, institutions or authorized social groups. The LP shareholders could be ‘state LP shares’ if the legal person entities are state-controlled. In contrast, a company may also issue LP shares to non-state investors who contribute non-state assets and these shares become standard LP shares.

Furthermore, the Chinese government has segmented the market in terms of shareholders into five; market for domestic A share investors, market for foreign B share investors, market for foreign H share investors, market for legal person shares, and finally a market for state shares. The listed firms have different market prices in each market, arbitrage among five markets is nearly forbidden. For example, for the firms issuing A share and H share, although H shares has been traded at discount ranging from 50% to 90% of their respective A share (Walter and Howie, 2003:179), there is no way or arbitrage mechanism to short A shares and buy H shares, because due to the restrictions on foreign exchange currency the Chinese citizens can only purchase very limited amount of foreign currency. On the other hand, no conventional stock markets exist in China for the transfer of LP and state shares. LP shares used to be transferred through management buy-out (MBO), and the shares were usually priced below net asset value (NAV), and far lower than A share's price (Walter and Howie, 2003:185). Chen and Chen (2007) discussed the undervaluation scandals along with MBO transactions, such as the unfairness revealed in MBO due to share mispricing, illegal sources of funding, and lack of transparency. As a result, MBO has been almost stopped since 2004 by the Chinese authorities, since then transferring LP shares has been carried out mainly through Mergers & Acquisition (M&A). State shares were transferred only among state entities at negotiable prices before non-tradable state-owned shares reform.

A distinct feature of ownership structures of the Chinese listed firms is the holders of non-tradable shares have exactly the same voting and cash flow rights as the holders of tradable shares; where, as we have mentioned before, these non-tradable shares cannot be traded publicly even though the company is publicly listed. Typically these shares belong to the state or to domestic financial institutions which are ultimately owned by the central or local governments. In other words, individual tradable shareholders bear market risk while non-tradable shareholders do not, but they enjoy the same rights. Furthermore, individual owners are discriminated against in terms of pricing, because they pay a higher price for their shares than non-tradable shareholders who are allocated their shareholdings prior to the IPO at price close to net asset value, which is far less than the IPO price.

By the end of 2002, only 6% of listed companies had non-tradable shares accounting for less than 40% of total equity capital, while only 0.4% of listed companies had no non-tradable shares at all (Green, 2004).

2.2.3 Non-tradable Shares Ownership Problems

i. Problem of asset-stripping

The direct consequence of the two-thirds non-tradable shares ownership structure leaves the market in a position to be manipulated by the institutional investors and local governments. The institutional state shareholders could easily make asset-stripping via cash dividend which is a regular way to pay out company profits. As reported by Green (2004), before April 30, 2003, 657 out of 1,236 listed companies declared either a cash or stock dividend. Among them, 622 listed firms paid a total cash dividends amounting to RMB 45.8 billion (US$ 5.5 billion), which is around 53% of these companies' total net profits. 'Retail A share investors suffer because LP shareholders pay substantially less for their shares than they do. It is therefore LP shareholders that predominantly benefit from cash dividends since all shareholders receive the same dividend. Of the RMB 45.8 billion (US$ 5.5 billion) worth of dividends announced by April 2003, the holders of traded shares received only RMB 16 billion (US$ 1.9 billion), the rest going to institutional state shareholders' (Green, 2004).

ii. Problem of performance deterioration after listing

The vast majority of researches on the question that whether the Chinese SOEs' performances have improved or deteriorated after listing in the stock market have failed to record any evidence of improvements. Allen et al. (2005) concluded, after a detailed analysis of national economic statistics, that it is the private non-listed sector of the economy that has driven China's economic growth. They argued that poor governance has constrained the performance of listed firms. Wang et al. (2001) investigated the impact of listing of firms with A shares; they documented that company performance declined significantly after listing. Chen et al. (2002) found that firm performances generally deteriorated both in terms of profitability and efficiency after listing. They showed return of equity and earnings per share generally declined during the 1990s; the only exceptions are the firms in the public utilities, transport and finance sectors. Huang and Song (2002) showed that even listing in Hong Kong stock exchange had no positive effects on performance improvements; which is in contradiction to general expectations that foreign ownership helps to improve firm performance.

iii. Problem of stock market speculation

The large proportion of non-tradable equity means that the share of stocks which are actually traded in the Chinese stock market is relatively small (see table 2.2). This is very small in comparison to mature markets, such as UK, US, and Hong Kong; these markets have market capitalization of over 110% of the free float/ GDP ratios. The extremely low float/GDP ratio of the China's stock market leads to a tremendously liquid and speculative market, because of the excess of demand over supply of the available stocks in the market (see table 2.3). Guo et al (2006) find evidence that for dually listed H (Hong Kong) and A (Shanghai) shares, the cost of capital is lower and liquidity measured by turnover ratio is far greater for A shares than those of their H shares counterparts.

Table 2.2 Ratio of Market Capitalization to GDP in China

	GDP *(RMB 10^8)*	Market capitalization *(RMB 10^8)*	% (Market Capitalization to GDP)	Tradable Market Capitalization *(RMB 10^8)*	% (Tradable Market Capitalization to GDP)
1992	26638.1	1048.13	3.93%	-	-
1993	34634.4	3531.01	10.20%	-	-
1994	46759.4	3690.62	7.89%	964.82	2.06%
1995	58478.1	3474.00	5.94%	937.94	1.60%
1996	67884.6	9842.37	14.50%	2867.03	4.22%
1997	74772.4	17529.23	23.44%	5204.43	6.96%
1998	79552.8	19505.64	24.52%	5745.59	7.22%
1999	82054	26471.17	31.82%	8213.97	9.87%
2000	89404	48090.94	53.79%	16087.52	17.99%
2001	95933	43522.19	45.37%	14463.16	15.08%
2002	102398	38329.12	37.43%	12484.55	12.19%
2003	116694	42457.72	36.38%	14178.52	11.29%
2004	159587	37055.57	23.22%	11688.64	8.56%
2005	183957	32430.28	17.63%	10630.51	5.78%
2006	209407	89403.89	42.69%	25003.64	11.94%

1. Source: NBSC, CSRC
2. Market Capitalization includes A and B shares only

Table 2.3 Turnover ratio of tradable A shares in SHSE and SZSE

	SHSE %	SZSE %
1992	-	265.45
1993	-	324.44
1994	-	691.79
1995	519.41	309.56

1996	760.05	949.68
1997	534.99	662.32
1998	355.30	411.14
1999	421.55	371.61
2000	504.07	396.47
2001	216.67	189.97
2002	208.74	200.65
2003	268.58	216.97
2004	308.31	311.78
2005	290.70	350.64
2006	564.50	671.34

Source: Shanghai Stock Exchange, Shenzhen Stock Exchange

iv. Problem of ownership structure

Apart from the small size domestic stock market, most of the domestic listed SOEs have small market capitalization with highly concentrated shareholders. At the end of 2002, 64% of the domestic listed SOEs had fewer than 50,000 shareholders and fewer than 5% had more than 150,000 shareholders (Walter and Howie, 2003:132). In terms of concentration of share holding, China is at a level similar to those in most West European countries (Faccio and Lang, 2002). What differentiates China’s ownership structure from the rest is the identity of the controlling shareholders; as the majority of the shares are owned, directly or indirectly, by the state.

Further, China's stock market was developed under a weak legal framework that offered minority shareholders little protection. La Porta et al. (1998) developed LLSV indicator[1] to measure shareholder rights protection, China scored 3, which was lower than the average score of 3.61 for all other transitional economies (Pistor and Xu 2005). However, some papers reported that the actual protection for shareholders in China is

[1] LLSV is the initial capital letter of four authors: La Porta, R., Lopez-de-Silanes, F., Shleifer, A., Vishny, R.

probably lower than what the index suggests (Tenev and Zhang 2002; Allen, Qian, and Qian 2005; Pistor and Xu 2005

In terms of the relationship between ownership structure and the performance of the Chinese listed firms, there are several papers in the literature. Qi, et al. (2000) studied all firms listed in the Shanghai Stock Exchange (SHSE) from 1991 to 1996, and found that the ownership structure composition and relative dominance by various classes of shareholders can affect the performance of the listed firms. Their empirical study suggested that firm performance increases with the degree of relative dominance of LP shares over state shares. Similarly, Hovey et al. (2003) indicated that though the ownership concentration has little explanatory power, the structure does matter. Legal person's shareholdings are positively related to firm valuation. Wei et al. (2005) investigated the relationship between ownership structure and firm value across a sample of 5,284 of China's partially privatized former state-owned enterprises (SOEs) from 1991-2001. They found that a significant convex relation exists between state and LP shares and Tobin's Q which measures firm's value. They also found that foreign ownership is significantly positively related to Tobin's Q. Ding et al (2007) analyzed 273 private-owned and state-owned Chinese companies listed in 2002; they revealed that an inverted U-shaped relationship exists between ownership concentration and earnings management practices. It is clear that private-owned listed companies tend to exaggerate their accounting earnings. However, the entrenchment effect of ownership concentration on earnings management is weaker in private-owned listed firms than in state-owned listed firms.

2.2.4 Hardening of the Budget Constraints and Non-tradable Shares Reform

Hard budget constraints are becoming an increasingly common feature for the Chinese listed firms. On the one hand; the state-owned commercial banks are decreasingly favouring SOEs and are putting greater emphasis on evaluating loan applications on their profit-making potential since bank officers are now personally responsible for their lending decisions. On the other hand, under pressure from the CSRC, the listed firms are less likely to make asset-stripping through dividends payments in cash. The benefit of liquidating state-owned shares on the secondary market is not only to 'clear the tangles in corporate governance, but the proceeds from the selling of state-owned shares can be used to offset the huge nonperforming loans and keep the capital adequacy ratio sufficiently high by the banking sector.' (Neftci and Menager-Xu, 2007: 232).

Under such situations, as well as the five-year slump of China's stock market, in April 2005, the China Securities Regulatory Commission (CSRC) launched a new approach for state share reform to make all non-tradable state shares become tradable on the market. This is an important landmark in China's stock market, to virtually privatize and change the control rights of the Chinese listed SOEs. The state share reform, as announced by the CSRC as a top priority in China, is the biggest reform in China's stock market history, and is critical for the privatizing process. Meanwhile, the timing for carrying out this reform seems to be perfect, after the market slumped during the past 4 or 5 years; the Shanghai Composite Index fell from over 3000 to less 1000, the market capitalization dropped by two-thirds.

The state share reform is a market-based negotiation between the private shareholders holding tradable shares and the state shareholders holding non-tradable shares. It is a market-based negotiation because the share merger gives ‘consideration’ to the private shareholders and uses ‘consideration’ to transfer trading rights. The consideration includes more bonus shares, warrants, and cash as compensation to holders of tradable shares. For example, in order for non-tradable shares to be tradable, each public shareholder will receive a certain number of shares, or a number of warrants, or certain cash as consideration. The public shareholders will decide at the shareholder meetings whether they considered it a fair consideration, whether they should accept it.

Further, foreign ownership inevitably became involved in this state share reform. In the last few years, the general legal and regulatory reforms have been upgraded to facilitate increased foreign ownership in listed companies. In the A share market, the tradable share market side, the QFII system was introduced in 2002 to open up foreign ownership in the public tradable share market. Then on the non-tradable share side, a series of mergers and acquisitions (M & A) rules were put into effect from 2002 to 2004. This new M & A framework has opened up foreign ownership in listed companies through acquiring non-tradable shares via private negotiations. For example, on October 25, 2005, Carlyle Group, an American private equity fund, announced a leveraged buyout of 85% of the claims Xu Gong Mechanism, the deal was worth by US$ 375 million. (Neftci and Menager-Xu, 2007:234)

So far, the literature about the Chinese state share reform is not very large, since this reform process is still ongoing and is yet to be completed. However, several papers such as Green (2003b) who gave an introduction about the background of the state share reform, and how it works and Beltratti and Bortolotti (2006) who reported that this reform process has generated a statistically significant 8 percent positive abnormal return over the event window.

Table 2.4 Chronology of state-owned shares reform

November 1999	Regulators approve the sale of a portion of state-owned shares by 10 firms
December 1999	Landmark sales of state shares in Guizhou Tyre and China Jialing Industry Motorcycle perform badly. As share prices are too high investors fail to take up much of the stock on offer. Beijing suspends planned sales for the eight other firms.
Jun 13, 2001	The State Council (the cabinet) requires all state-owned firms planning IPOs as well as listed firms issuing more shares to raise the equivalent of 10% of the offering by selling state shares. The money must be given to the National Social Security Fund to help finance the Public welfare system. This is the first full-scale attempt to solve the problem of state-owned shares. The aim is to allow all shares eventually to be traded on the market.
October 23, 2001	Regulators suspend the reform as a result of 30% slide in the benchmark index in just three months. Expectations that Beijing will eventually sell state shares haunt the market thereafter, pushing down share values whenever rumours about the program emerge.
April 29, 2005	Beijing issues rules to revive the state-owned share reform. The approach is made more attractive to investors by requiring companies to win approval of two-thirds of public shareholders before floating state-owned shares. Also, a phased, three-year limit on the number of shares that can be sold to the market is established.
May 9, 2005	Sany Heavy Industries Co. and Tsinghua Tongfang Co. start the reform on a trial basis.
May 10, 2005	Four companies announce plans to give compensation, in cash and bonus shares, to public shareholders; the aim is to encourage a favourable vote by shareholders.
May 25,2005	China quietly suspends IPOs, to ease investor worries about the supply of new shares coming to the market.
June 1, 2005	China’s shares end at their lowest level since early 1997 on renewed worries concerning state-owned share sales.
June 20, 2005	Regulators pick the steel mill Baoshan iron and Steel and Three George Dam operator Yangtz Electric Power to be among 43 firms subject to the reform.
August 24, 2005	Regulators open the reform to all 1,400 listed firms.

September 12, 2005	Forty firms, including Minsheng Banking Corp., announce they will voluntarily adopt the state-share reforms. The group of companies joining the reform scheme begins expanding quickly.

Source: Neftci and Menager-Xu, 2007

2.3 The segmented market with price puzzle

The shareholder structure of a Chinese listed firm is around two-thirds non-tradable shares plus one-third tradable shares, and the tradable shares could be owned by domestic investors as A share holders or foreign investors as B or H share holders. Although these different shareholders have the same voting rights and cash flow rights, they have to pay different prices for each type of shares. For example, the domestic investors have to pay much higher price for A shares while an investor from Hong Kong or the US pay considerably low prices for shares which provide them with the identical rights and benefits to those of an A share holder. The price differentials persist all along since the beginning of the China's stock market, and there is no way for the domestic Chinese citizens to arbitrage between A share market and B/H share market due to the restrictions on exchange currency; likewise there is no way for foreign investors to earn arbitrage profit just simply because they do not hold Chinese citizenship.

2.3.1 A shares

On the domestic stock exchanges, a firm may issue tradable A shares and B shares. The A shares can only be traded by mainland Chinese investors, from December 2002; certain qualified foreign institutional investor (QFII) may also trade in the A-share market.

2.3.2 B shares

Like many other stock markets in emerging countries, China's stock market has placed explicit restrictions on foreign ownership from its beginning. In 1992, the CSRC allowed companies to issue the so-called 'Special Shares' (later, designated as B shares) which were the only shares in China's stock market foreign investors have access to. In Shenzhen stock exchange, the B shares are denominated in Hong Kong dollars, and in Shanghai stock exchange; they are transacted in US dollars. The shareholders of both A and B shares are recognized to have equal status by the Securities Law of China. By December 2006, there were a total of 109 firms with B share listing. 86 of these companies also listed their shares as A shares while 23 of them did not. B share market constitutes a very small proportion of the whole market; it accounted for less than 5% of the overall market capitalization and trading volume during the past decade (CSRC website).

A shares and B shares have different accounting standards and information disclosure requirements. International Accounting Standards (IAS) are used to prepare accounting reports for the B share firms, while China's accounting regulations, PRC Generally Accepted Accounting Principles (PRC GAAP) are used to prepare accounting reports for the A share firms. The IAS is more conservative than the PRC GAAP, so the level of disclosure for the B shares is higher than that for the A shares. Therefore, the profit values, asset values, and book values etc. are different between the IAS and PRC GAAP statements. The B share companies need to prepare two sets of financial statements: one is based on IAS for the B share holders, and the other is based on PRC GAAP for the A share holders[2]. The PRC GAAP and IAS numbers are released to the shareholders on the same day, and the differences between the two sets of numbers are disclosed in the PRC GAAP statements as well as the IAS statements, so there are no information barriers or advantages to either the A share holders or the B share holders.

Although segmented markets are not unique to the Chinese stock market, the Chinese market is distinctive because of its complete segmentation. The segmentation in most other markets is only partial, foreign investors are allowed to own the foreign category of shares only, while domestic investors can own both local and foreign shares. A price discount puzzle arises in China since in this market, though A and B shares have identical voting rights and cash flow rights, A shares continue to be traded at a higher price premiums relative to the corresponding B shares. However, this contradicts most other findings on the impact of foreign ownership restrictions on asset returns. For example, Hietala (1989) for Finland stock market; Lam and Pak (1993) for Singapore; Bailey and Jagtiani (1994) for Thailan; Stulz and Wasserfallen (1995) for Switzerland; Domowitz et al. (1997) for Mexico; and Bailey et al (1999) for stock markets in 11 countries -- all these studies gave supportive evidence that shares available to foreigners are usually priced at a premium relative to that of the domestic shares, which are otherwise identical but only for the domestic investors. China is the only exception, where foreign B shares are priced at huge discounts compared to the price of the domestic A shares.

A number of papers have studied the B shares' price discount puzzle, and tried to explain it from several aspects associated with China's capital markets. The most

[2] Major differences between PRC GAAP and IAS are summarized by Bao and Chow (1999)

important papers include Bailey (1994), Ma (1996), Chakravarty, Sarkar and Wu (1998), Chui and Kwok (1998), Poon, Firth and Fung (1998), Fernald and Rogers (2002), Sun and Tong (2000), Chen, Lee and Rui (2001), Eun, Janakiramanan and Lee (2001).

Bailey (1994) was the first to uncover the discount puzzle; he attributed it to the lower opportunity cost of capital for the A shares, because there was nearly no alternative investment vehicle available for the domestic citizens other than low-yielding bank accounts. As a result huge amount of Chinese domestic savings were driven into stock investments. The limitation of the above research is the small sample size that only covered the preliminary data of 8 listed companies for one year time period. In addition to the low cost of capital as suggested by Bailey (1994), Ma (1996) also proposed some other explanations, such as different attitudes towards risk between A share and B share investors, differences in liquidity between A share and B share markets, portfolio diversification intention of foreign investors, and different reactions of domestic and foreign investors to regulation changes. Chen, Lee and Rui (2001) found evidence that high B share price discount is primarily due to the illiquid B share market, so B share have a higher expected return and lower price to compensate investors. Adopting a similar approach as Bailey (1994), Fernald and Rogers (2002) also showed evidence that domestic investors have lower expected return than foreign investors, and which is due to lower risk that Chinese citizens were exposed to.

Apart from the explanation related to liquidity and cost of capital, Poon, Firth and Fung (1998) proposed that the theory of 'investor recognition' may constitute an important explanation for pricing behaviour in a segmented market. The theory of 'Investor recognition' was suggested by Merton (1987) according to which 'an increase in the size of the firm's investor base will lower investors' expected returns and increase the market value of the firm's shares'. Poon et al. (1998) studied the impact of issuing B shares on the price of existing A shares, and found a significant negative abnormal returns on the A share firms which also issued B shares; which implies that the demand curve for equity shares is downward sloping.

Another line of study on the B share discount is 'substitute effect' proposed by Sun and Tong (2000), which used the model by Stulz and Wasserfallen (1995). Basically, they suggested Chinese H shares and Red Chips listed in Hong Kong, as well as the Chinese ADRs listed in the US offer good substitutes for the B-shares listed in Shanghai and Shenzhen, so foreign investors have more elastic demand for China B-shares. The availability of these stocks in the US and Hong Kong means that foreign investors can get them from the US or Hong Kong markets instead of from the B share markets in Shanghai and Shenzhen. Yang and Lau (2005) extended the substitute effect of Sun and Tong (2000); they found that the number of shares and trading volume of the Chinese firms traded in the US are also significantly negatively related to the B share premium. The substitute effect from these stocks is stronger than that from the Chinese stocks listed in Hong Kong.

Finally, some papers suggest the information asymmetry pattern related to the Chinese segmented stock market can clarify this discount puzzle. Chakravarty, Sarkar and Wu (1998) developed a model by involving a proxy measuring asymmetric information between A and B share investors, they argued that it is because foreign investors have less information about the local firms, relative to domestic investors that leads to the B share discount. On the other hand, Chui and Kwok (1998) argued because of the information barriers in China, foreign investors are better informed, due to strict disclosure requirements in the overseas stock exchanges, than the Chinese domestic investors with respect to the value of the Chinese stocks, and they found robust results of the asymmetric cross-autocorrelation between A share and B share in terms of lagged returns and trading volumes. Bergstrom and Tang (2001) adopted asymmetric information measurements of Chakravarty, Sarkar and Wu (1998), as well as considered other factors, such as liquidity effect measured by bid-ask spread and relative trading volume; diversification effect measured by the correlation of B share return and portfolio return; client bias effect; company size; risk-free return differentials between foreign and domestic investors; and foreign exchange risks, and reported all these factors are significantly related to B share discount.

At the end of 2000, there were 29.433 million A share accounts and 0.145 million B share accounts on the SHSE. On the SZSE, the figures were 28.303 million and 0.129 million for the A and B share accounts respectively. The dramatically small and inactive B share market has troubled the Chinese authorities for a long time. As early as in April and June of 2000, Tu Guangshao, the president of the Shanghai Stock Exchange, and Dai Xianglong, the governor of the People’s Bank of China, acknowledged that difficulties existed in the B share market but expected them to be resolved with greater internationalization of the markets through, for example, the liberalization of the capital account. Almost one year later, on February 19, 2001, the CSRC announced that domestic investors would be allowed to open trading accounts for B shares.

In one research carried out after the introduction of the new market regulation in China, Karolyi and Li (2003) observed wide-ranging differences in the discount changes across their sample of stocks. B-share discounts ranged from 56 percent to 90 percent before February 19, 2001, however, after that date, the discounts ranged from *premiums* of 381 percent to discounts of 56 percent. And only for small market capitalization and with substantial past-return momentum, the B share discount has declined from the period when this regulatory change was announced. However, this decline is found to be unrelated to the firm's risk and liquidity attributes.

2.3.3 H shares

For its special geographical and political reason, Hong Kong is the favourite overseas market place of the Chinese government to list firms, especially SOEs. Tsingtao Beer became the first Chinese SOE to list directly on the SEHK in July 1993, and raised capital of approximately US$115 million. 'As of February 2006, a total of 125 Chinese companies had listed H shares on the Hong Kong and overseas stock exchanges, raising US$ 55.907 billion,…,31 of these H share companies had also issued and listed A shares domestically (Neftci and Menager-Xu, 2007:6)'.

The Chinese H share firms act more like the Hong Kong listed firms rather than the Chinese listed firms which only issue A shares and the performances of the H share firms are better than those of firms issuing only A shares. The main reasons may come from several aspects of the markets, such as the legal system of Hong Kong which helps to bring better corporate governance practice, high accounting standards in SEHK which offer sufficient information release, and artificially packaging of the SOEs before their listing in Hong Kong (Huang and Song, 2005).

In contrast to mainland China's civil law system, Hong Kong maintains the common law tradition established by the British colonial rule. Although Hong Kong has been a special administrative region of China (HKSAR) since 1 July 1997, the Basic Law of Hong Kong allows Hong Kong's courts to refer to decisions under the jurisdiction of common law. As reported by La Porta et al. (1997) that the common law provides sounder legal protections for minority investors, as in the US and UK.

Second, in order to satisfy the needs for listing in Hong Kong and promote competition with their international peers, the listed SOEs have been restructured before they issue international offering. The typical restructuring methods is to separate productive heart of the SOEs and establish them as companies, and leave the other non-profit making part such as social and ancillary service operations to the parent company. It is very likely that there are some "dressing-ups" for the listed firms during the packaging process. Nevertheless, it is expected that company performance should improve because of the restructuring.

Finally, the H firms are obliged to provide annual financial reports in accordance with Hong Kong or international accounting standards. And all these firms are required to recruit Hong Kong certified public accountants for their audits. It is reasonable to expect the information from these companies to be more reliable than those from the other companies in China that are not listed overseas.

Some papers compared H firms with A firms or B firms with regard to companies performance, which include Aharony et al. (2000) who examined the earnings pattern of 83 newly listed B and H firms in China from 1992 to 1995, and found that SOE managers have different incentive and opportunities for earnings management, they attributed the reasons to the firm's relation with the government and the location where its shares are listed; they reported a statistically significant post-issue earnings decline for unprotected industry firms, they also found that the H firms exhibit smaller post-IPO return on assets decline than B firms. Wang and Jiang (2004) examined the Chinese companies' cross-listed in mainland China (A shares) and Hong Kong (H shares). They documented a large time-varying H share price discount relative to that of A shares, and they attributed this discount to domestic and foreign market factors and relative market illiquidity. They also reported that H shares exhibit significant exposure to Hong Kong market factors and behave more like Hong Kong stocks than the mainland Chinese stocks. Guo and Tang (2006) compared the price differences between H and A shares. They found that the Chinese mainland investors require lower rate of returns than foreign investors, and liquidity is greater in the A share market, which is contrary to the conventional wisdom that firms cross-list to achieve lower cost of capital and greater liquidity. Their results also indicate that differences in cost of capital and liquidity between the two markets contribute to the price difference between the Chinese A shares and their matching H shares. Eun and Huang (2007) studied asset pricing mechanism of China's stock market, and revealed domestic A share investors would value A shares more if there are B and H shares counterparts, which suggested that a Chinese firm with a foreign shareholder base has a lower cost of capital.

2.4 Stock Exchanges, Transaction Costs, and Trading Mechanisms

We have analysed the unique characteristics of the Chinese listed firms and the segmented sub-markets for A, B and H share holders. O'Hara (2001) emphasized the importance of that 'the price discovery and liquidity are affected by market environment and the characteristics of the firms themselves'. We then proceed to discuss the market microstructure and trading costs of the three China-related stock exchanges. Xu (2000) studies the microstructure of the China's stock market with regard to the trading mechanisms design, as well as empirically investigates trading volume and volatility relation of the market index (Shanghai Composite Index). Our study will focus on the impact of the trading mechanisms on the trading costs and liquidity, because trading costs and liquidity is critical in determining stocks' price discovery and firms' listing decision, it would be helpful for understanding why the Chinese SOEs' listing patterns are different from that of the private firms.

2.4.1 Transaction Costs and Liquidity

Although the Shanghai Stock Exchange and the Shenzhen Stock exchange have adopted advanced electronic trading systems, it is no guarantee that the two stock exchanges will work as efficiently as the stock exchanges in Hong Kong, New York and similar others. As mentioned by Harris (2003:420) that 'Exchanges conduct transaction cost measurement studies to document the quality of their markets.' When we value the efficiency of a stock exchange, one important point that must be considered is transaction costs; because low trading costs helps traders trade efficiently, for example traders can minimize transaction costs of a given size, or maximize size for a given cost.

'Transaction costs include all costs associated with trading. These costs include explicit cost, implicit cost, and missed trade opportunity costs' (Harry, 2003:421). Explicit costs are those costs which include brokerage fees, exchange charges and the taxes applicable on the transactions when these are executed. Implicit costs such as market impact costs cannot be easily identified and measured. Market impact costs usually arise because traders have an impact on prices, especially when a large order is executed in a very short period of time. And it is easy to understand that the price changes are usually adverse in terms of the initial trading; for example, selling drives prices down, and vice verse. So the initiator has to spend part of his funds under management to purchase liquidity. Missed trade opportunity costs arise when traders fail to fill their orders or fail to fill their orders in a timely manner.

Competition among brokers to attract large number of investors tends to decrease the explicit costs, as it seems to happen nowadays. However, the implicit cost is more or less out of the investors' control, because it depends mainly on the market conditions. Reduction of the implicit cost is a key factor for enhancing the returns on an investment.

The factors determining market impact costs include the volume of the transaction, the market liquidity, and market depth. Large volumes of transactions tend to incur large market impact costs for a given liquidity condition, and vice verse. But the liquidity condition of the market rather than the size of the transaction have a greater influence on market impact costs. In a highly liquid market, the bid ask spread can be narrowed down, so even a large volume of transaction can be easily executed with lower cost. Market depth is the size of an order needed to move the market by a given volume of trade. Partial execution arises when the depth of a stock market is not sufficient to complete the transaction. This will result in an adverse price movement, because the remaining part of the transaction has to generate additional depth on the opposite side, which may result in a higher (lower) price in buy (sell).

2.4.2 Trading mechanisms

Madhavan (1992) examined how different trading mechanisms affect the process of price formation, and argued 'the crucial function of a trading mechanism is to transform the latent demands of investors into realized transactions.' And 'no two trading mechanisms are alike in the performance of price discovery; they differ in the types of orders permitted, the times at which trading can occur, the quantity and quality of market information made available to investors at the time of order submission, and the reliance upon market makers to provide liquidity'.

Trading mechanisms can be classified into continuous and periodic mechanisms based on the time at which trading occurs. In a continuous market an investor's order is executed immediately upon submission, where full transparency is provided of the limit order book. The periodic system (commonly referred to as a call auction or batch market) is characterized by a set of multilateral transactions at a given price, where the orders are matched periodically at the mid price of the quotes. The latter system doesn't provide any independent price discovery mechanism. No single system is ideal for a market. The decision to adopt continuous or periodic call auction matching depends on the market dynamics. A market system which prefers greater transparency and favors retail investors would more likely want to adopt a continuous matching system enabling the investors to view the full limit order book and decide on the price of the instrument traded. This limit order book disclosure may not be favorable for a large institutional investor who generally places orders for a large quantity. Disclosure of full order book will result in more impact cost for the institutional investor. An institutional investor would rather prefer to hide its order from the market and execute at an average price. Normally markets, which operate on continuous matching system, tend to adopt call auction mechanism and single price execution whenever trading is resumed from market halt. The reason behind this is that this type of trading ensures that the information accumulated during the halt period should be factored in the price of the asset once the trading is resumed from halt. So a brief pre-opening session is held (before the continuous trading is resumed) to accumulate the orders and orders are executed based on call auction mechanism.

On the other hand, based on the reliance upon market makers to provide liquidity, market microstructures may be classified into quote-driven (such as NASDAQ) and order-driven trading mechanisms (such as NYSE), In a quote-driven system, investors can obtain firm price quotations from market makers prior to order submission. This mechanism is also known as a continuous dealer market because an investor need not wait for order execution, but instead trades immediately with a market maker, the market maker supply all the liquidity. In pure quote-driven markets, dealers participate in every trade. Anyone who wants to trade must trade with a dealer, traders either negotiate with the dealers themselves, or their brokers, acting as their agents. The dealers frequently trade among themselves, but public traders cannot trade with each other.

By contrast, in an order-driven system, also known as auction system, investors submit their orders for execution through an auction process, order-driven mechanisms can operate either as continuous systems or as periodic systems, in the first type, known as continuous auction, investors submit existing limit orders submitted by public investors or dealers. The system is continuous, since orders are executed upon arrival, but operates as an auction because the price is determined multilaterally. The second type of order-driven system is known as periodic auction, where the orders of investors are stored for execution at a single market clearing price. In order-driven markets, buyers and sellers regularly trade with each other without the intermediation of dealers; these markets have trading rules that specify how they arrange their trades. In order-driven markets, traders can offer or take liquidity; traders who offer liquidity indicate the terms at which they will trade. Traders who take liquidity accept those terms.

Compared to auction market (order-driven market), dealer market (quote-driven market) has more impact on liquidity, because of narrower spreads in the dealer market, informed traders are less likely to take utmost advantage of the special information that they have. The spread also depends on the market makers inventory as market makers trade based on their inventory position. A balanced inventory position of a market maker will result in narrower spreads due to the pressure on the market maker to maintain his inventory being less. But too many long or short position will result in high pressure on market maker's inventory that results in wide spreads in the market maker quote.

In the following sections, we will contrast transaction costs (explicit and implicit costs) among three China-related stock exchanges, we also compare this three stock exchanges by examining the market condition including market size, trading value, trading hours and trading days, and describe the market mechanisms of each market, including trading mechanisms, clearing and settlement systems, and market maker system, etc, and the policy tools used by the regulatory authorities to control market volatility, such as short-selling restriction, daily price limits, and tick size.

2.4.3 Transaction costs of three China-related stock exchanges

As discussed above, transaction costs include explicit costs and implicit costs. It is easy to quantify explicit costs which mainly take account of brokerage fees, exchange charge and the taxes applicable on the transaction when it is executed. However, it is difficult to accurately measure implicit costs, i.e. market impact costs and opportunity costs. Market impact costs can be explained by trade size, trade direction (i.e. buys or sells), stock size, investment style, and the type of institution executing the trade package, and is directly related to the size of the trade executed by an institutional investor. Normally larger volume transactions are expected to incur higher market impact costs, the reason is because that larger trades will account for a higher proportion of total trading volume, and hence the size of an order can cause an adverse shock in the price of stock. Other implicit costs in trading are opportunity costs incurred by patient traders seeking to avoid market impact costs (i.e. the value lost due to information decay). Hence, there exists a trade-off between market impact and opportunity costs.

2.4.3.1 Explicit costs of the SHSE (SZSE) and HKSE

We summarize explicit costs of Shanghai stock exchange (Shenzhen stock exchange), and Hong Kong stock exchange in table 2.5. The two mainland China's stock exchanges charge the fees in the different way that Hong Kong stock exchange does, especially for the transfer fee, two China's stock exchange charge 0.1% per side of the transaction value while Hong Kong stock exchange charges HK$2.50 per share, when stocks' prices are relatively high, the way charging in terms of 'per share' will lead to low transaction costs. So, it is hard to conclude which market demand high explicit costs.

Table 2.5 Explicit costs of the SHSE, SZSE and HKSE (2006)

Stock Exchange	SHSE (SZSE)	HKSE
Brokerage	0.3%, (minimum RMB 5.00)	0.2% - 0.5%,
Stamp Duty	0.3% per side of the transaction value	0.1% per side of the transaction value
Trading Fee	N/A	0.005% per side of the transaction value
Transaction Levy	N/A	0.004% per side of the transaction value
Transfer fee	0.1% per side of the transaction value	HK$2.50 per share

Source: Fact books (2006) of Shanghai Stock Exchange, Shenzhen Stock Exchange, Stock Exchange of Hong Kong

2.4.3.2 Market impact costs of the SHSE (SZSE) and HKSE

Traders estimate market impact costs by using specified price benchmark methods and econometric methods of estimation of transaction cost. The price benchmark methods are the most commonly used, because they are easier to implement than the econometric methods. So, the estimated cost would be relative to trade size and the difference between trade price and benchmark price (Harris 2003:422).

Estimated Cost = Trade Size * Trade Sign * (Trade Price – Benchmark Price)

Trade Sign = 1 for a purchase / -1 for a sale

The 2006 annual report by the SHSE research institution about market quality provides a comparison of transaction costs on the SHSE chronologically as well as comparison of transaction costs among different stock markets. They reported the market impact costs on the SHSE based on a transaction value of RMB 100,000 from 1995 to 2006. According to the report, the basis point of market impact costs is on a decreasing trend on both buy and sells sides (see Table 2.6). This annual report also compared the market impact costs on the SHSE for the same time period when transaction values are respectively RMB 100,000, RMB 250,000, and RMB 900,000, and found all market impact costs based on different levels of transaction value dropped year by year, but large value of trades has much higher impact on the transaction cost (see Table 2.7). Further, they compared the market impact costs on the SHSE, HKSE, NYSE, and NASDAQ, and found that the SHSE has the highest market impact cost, while NYSE has the lowest costs (see Table 2.8).

Table 2.6 Market impact costs on the SHSE for one transaction value (based on a transaction value of RMB 100,000)

Unit: basis point

	1995	2000	2005	2006
Buy	259	85	73	49
Sell	140	81	62	46

Table 2.7 Market impact costs on the SHSE for three transaction values (transaction values are respectively RMB 100,000, RMB 250,000, and RMB 900,000)

Unit: basis point

	1995	2000	2005	2006
RMB 100,000	399	166	135	95
RMB 250,000	853	229	223	157
RMB 900,000	4231	343	359	293

Table 2.8 Market impact costs on the SHSE, HKSE, NYSE, and NASDAQ

Unit: basis point

SHSE	SEHK	NASDAQ	NYSE
95	13.5	14.67	8.67

2.4.4 SHSE, SZSE, and SEHK

2.4.4.1 The market condition

The SHSE and SZSE have adopted a market trading system based on modern computerized and telecommunications technology and fully practiced electronically automated trading. The system automatically matches the closest offer and bid and works remarkably well in practice. Based on the principle of price priority and time priority, the system offers concentrated bidding and matches offer and bid deal by deal, with a daily capacity of 10 million commissions. Most of the firms listed in the SZSE are small, joint venture firms, and since 1994, the SZSE has been over taken by the SHSE in terms of market capitalization, trading volume, and number of listed shares (Xu, 2000).

Recently, the government has decided to merge the SHSE and SZSE into an integrated main board market. The listed companies on the main board of the SZSE will move to the SHSE in two to three years time, while the SZSE will be dedicated to Growth Enterprise Market. The Chinese authorities have realized that ‘stock exchanges around the world are rushing to establish alliances and partnerships with one another that could lead to outright mergers and acquisitions.’ An article in Asia Times (June 30, 2007) pointed out that ‘This cooperation between two Asian bourses has given a renewed impetus to the idea of creating a link between the Hong Kong Stock Exchange (HKSE) and the Shanghai and Shenzhen exchanges as many mainland companies are listed on both bourses.’

The Stock Exchange of Hong Kong (SEHK) ranks fifth in the world in terms of market capitalization of listed companies (2006), and is classified by the International

Finance Corporation (IFC) and World Bank as a developed market. Hong Kong is a free market economy with well established regulations for finance and commerce. Non-residents can efficiently trade in Hong Kong stock exchange. Hong Kong dollar is internationally exchangeable at a stable fixed rate against the US dollar (1USD= 7.8 HKD). The history of the securities exchange of Hong Kong began in the late 19th century. The exchange has predominantly been the main exchange for Hong Kong despite co-existing with other exchanges at different points in time. After a series of complex mergers and acquisitions, HKSE remains to be the core. In 1993 the exchange launched an 'Automatic Order Matching and Execution System' (AMS) that was replaced by the third generation system (AMS/3) in October 2000. These systems were added to meet the increased popularity of online stock trading[3].

2.4.4.2 Trading hours and trading days

The SZSE and SHSE open from 9:30 am to 15:00 pm with a lunch break from 11:30 am to 13:00 pm. There is a pre-trading session from 9:15 am to 9:25 am each day; the morning opening prices are generated during that session. Thus we see a hybrid of periodic auction and continuous auction trading mechanism in the two markets under discussion; the periodic auction is used once a day to generate the opening price. During the rest of the trading time, continuous auction is used to match transactions. They open 5 days a week except for holidays; the SZSE has more holidays than the SHSE during the Chinese New Year period, and both exchanges have fewer trading days than the SEHK.

[3] More information can be found in HKEx website, http://www.hkex.com.hk

The SEHK opens 5 days per week, and the trading hours is from 10:00 am to 12:30 pm and from 14:30 pm to 16:00 pm. Like stock markets in most countries and economies in Asia, the SEHK has adopted a continuous auction market microstructure.

Table2.9 Market condition, Trading hours and Trading days (SHSE, SZSE, and HKSE, 2006)

Stock exchange	SHSE	SZSE	HKSE
Number of listed firms (including domestic and foreign firms)	842	579	975
Market capitalization (US $ billions)	898.50	222.39	1,687.00
Market capitalization of tradable shares (US $ billions)	206.13	107.19	-
% (Market capitalization/GDP)	34.19%	8.50%	115%
% (Tradable Market capitalization/GDP)	7.85%	4.10%	-
Trading value (US $ billions)	725.40	408.15	1,069.00
% (Trading value/Total market capitalization)	80.74%	183.52%	62.89%
% (trading value/tradable market capitalization)	351.9%	380.76%	-
P/E ratio	33.38	33.61	17.37
Dividends yield	-	-	2.19
Trading hours	9:30 -11:30 13:00-15:00	9:30 -11:30 13:00-15:00	10:00-12:30 14:30-16:00
Trading days	241	241	247

1. Source: Fact book of each stock exchange, 2006
2. Market capitalization and Trading value include A and B shares only
3. In 2005, China adopted floating exchange rate, according to http://www.pbc.gov.cn/, the average exchange rate of USD to RMB in 2006 is 1USD=7.97RMB, and we convert RMB to USD at a yearly average exchange rate. Hong Kong has been pegged its exchange rate to USD at 1USD=7.8 HKD since 1983.
4. China and Hong Kong are in the same time zone

2.4.4.3 Trading mechanisms

First, like many other mature markets employing multiple trading mechanisms (for example the NYSE and NASDAQ are both hybrids of dealer market and auction market), the two young Chinese mainland exchanges are hybrids of periodic auction (9:15am-9:25am of every trading day) and continuous auction (9:30am-15:00am of every trading day). During the periodic auction, all orders are matched on the basis of price priority, while during the period of continuous auction; all orders are matched according to the principle of price as well as time priority. The periodic auction applies once per day to determine the morning opening prices. All bidding orders are set from high to low, and all asking orders are set from low to high, the final execution prices get determined between the highest bidding price and the lowest asking prices and as many as pre-trading orders as possible are executed. The continuous auction is used during the rest of the trading hours in terms of time and price priority, so that each transaction price is the equilibrium price determined by the demand for and supply of securities at each spot of time. Compared to periodic auction, market volatility tends to be higher in continuous auction.

In Hong Kong, the continuous auction method is used throughout the trading day and also determines opening and closing prices.

2.4.4.4 Clearing and settlement systems

The registration and clearing of securities is centralized through the China Securities Depository and Clearing Corporation Ltd. (CSDCC). Before trading in a stock exchange, an investor must place all the securities (fully dematerialized) into an account opened with the CSDCC. Currently, the settlement for A shares is T+1 and the settlement for B shares is T+3. (Neftci and Menager-Xu, 2007:15)

The China Securities Depository and Clearing Corporation (CSDCC) is the only securities depository and clearing corporation registered with the State Administration of Industry and Commerce in compliance with the Securities Law of the People's Republic of China and the Company Law of the People's Republic of China. CSDCC is based in Beijing with subsidiaries in Shanghai and Shenzhen. It operates under the supervision of the China Securities Regulatory Committee (CSRC). CSDCC was founded on March 20, 2001, with the approval of the State Council and CSRC. (http://www.chinaclear.com.cn)

The Hong Kong Securities Clearing Co Ltd (HKSCC) is the clearing company for transactions relating to stocks and a variety of other SEHK-traded securities, traded-options on the SEHK. The HKSCC started to operate on May 28, 1992, and the settlement period is T+2.

2.4.4.5 Floor based trading vs. Automated trading system

Unlike the NYSE, the two exchanges in China have almost no floor traders or floor brokers; buy and sell orders are matched through a telecommunications network but not on the actual trading floor. Electronic trading system is now widely used around the world which differs from the traditional trading methods such as floor trading in several ways. The most marked advantage of electronic trading system is that it helps to improve market liquidity by reducing bid-ask spreads; however, when trading volume increases at times of market stress, it underperforms a floor-based trading system by widening the bid-ask spread. As Stoll (1992) pointed out, there are disadvantages of an automated system which affect several aspects of market structure such as risk bearing, free trading options, informational trading, reputation building, and anonymity. Venkataraman (2001) also mentioned that institutional investors prefer to use the floor broker to "work" large and difficult orders. This is because the floor brokers can reduce market impact and execution costs by reacting quickly to the changes in the market conditions and execute sophisticated trading strategies.

Hong Kong abandoned floor trading system since 1993 when Automatic Order Matching and Execution System (AMS) replaced the traditional trading system. (McGuinness, 2000:85).

2.4.4.6 Market marker system

There is no official market marker system in SZSE and SHSE. Market makers, also known as specialists in the NYSE, 'provide liquidity on demand in small quantities. They often trade in and out of their positions many times a day.' (Harris, 2003:195) Market maker system is helpful in promoting market liquidity and the depth of market. Another important role of the market makers is to stabilize stock prices. Market makers have their own inventory position; they must adjust purchasing and selling out of their own inventory to balance the market when there's a demand-supply imbalance of a particular security. 'The lack of official market maker system in the SZSE and SHSE could be a main reason for the two exchanges to have low liquidity (measured by the bid ask spread) and high transaction cost.' (*Shanghai Stock Exchange Trading Quality Report, 2006, in Chinese language*)

On the SEHK, the number of market maker is 21 by the end of 2006 (SEHK Fact book, 2006), since SEHK employs electronic matching system, market makers are only required to quote two way prices at specified times to enhance liquidity of the markets.

Comparing with the NYSE and NASDAQ, we can find out one of the distinctive characteristics of the three China-related stock exchanges is that, the block trading in those three exchanges are very limited because block trading are normally executed by market makers, however, block trading in the US stock market account for about 50% of daily trading, therefore, we can clearly see the big difference in the trading costs and liquidity among these markets.

2.4.4.7 Over-The-Counter (OTC) Market

Unlike the US where a multilevel financial trading system has been built up, China has only two national stock exchanges and no stock exchange at the provincial level. The Chinese authority had launched two OTC markets in the late of 1980s with only very limited informal exchanges and trading, however, due to lack of effective supervision and regulation, these two markets were closed in 1999, and the decision to re-open these is still under discussion.

2.4.4.8 Short selling practice

Short-selling practice is quite popular in the developed stock markets, especially in the

US markets, which is an investment strategy used by speculative investors who try to profit from the falling price of a stock. Short-sellers usually borrow a security (or commodity futures contract) from a broker before selling it, with the understanding that it must later be bought back (hopefully at a lower price) and returned to the broker. The two Chinese exchanges have strict restriction on short-selling, while Hong Kong has relaxed the restrictions on short-sells gradually since 1994, when 17 designated securities could be sold short in a pilot scheme. The number of these designated securities has increased over time and at present; there are 527 securities eligible for short-selling according to the official website (www.hkex.com.hk).

2.4.4.9 Tick size

Most stock exchanges have regulations on tick size which is minimum allowable price movement. Tick size is one of the factors attributing to affect market liquidity, if the size is too large; traders are reluctant to improve prices because of the expense involved. The Stock Exchange of Hong Kong (SEHK) has different levels on tick size according to different scales of stock price, for example, when stock price is between HK$ 0.01 to HK$ 0.25, the tick size is HK$ 0.001, when stock price is between HK$ 0.25 to HK$ 0.50, the tick size is HK$ 0.005.[4] On the SZSE and SHSE, the tick size for quotes on A shares is RMB 0.01yuan. Huang and Stoll (2001) reported in their empirical study on the stocks traded on the London Stock Exchange (LSE) and their respective ADRs traded on the NYSE, that the lower restrictions on tick size will cause the higher spreads, higher quote

[4] http://www.hkex.com.hk/rule/exrule/sch-2_eng.pdf

clustering and higher market depth[5].

2.4.4.10 Daily price limits

Both SHSE and SZSE applies a 10% price cap for both rise and fall margins within the day for shares and funds trading to maintain market stability and keep away from dramatic fluctuations in share prices. However there is no limit imposed on the HKSE.

2.5. Conclusions

We have studied the features of the three components of the domestic market, the listed firms, the investors, and the stock exchanges. With regard to the listed firms, we analyzed the root of the ownership structure problems. After an introductory survey of the historical motivations of the Chinese government to create the stock market and enlist the SOEs, we concluded that the state owned non-tradable shares of the listed firms have been an obstacle for the development of China's stock market and the performance of the listed firms. We then focused on the important non-tradable shares reformation which started from 2002; the reform policies and the impact on the market were reviewed.

With respect to the investors, we have shown how the investors were artificially grouped into three segmented sub-markets, the A shares, B shares, and H shares sub-markets. We have also reviewed the literature studying the price discount puzzle that

[5] On the NYSE, the tick size was US$ 0.125 before June 24, 1997, and has been US$ 0.0625 since then until 2000, when the size was decreased to US$ 0.01. However, there is no limits on tick size on the LSE

addressed that the A shares prices have been much higher than the prices of B shares and H shares. By reviewing the important published papers about this issue, we have made the following conclusions; first of all, the B shares listing do not make any contributions to the listed firms to improve their operation, even though B shares were initially issued only to the foreign investors. Unlike the firms issuing A and B shares, the firms with H shares listed in Hong Kong behave more like the Hong Kong firms rather than like the mainland Chinese firms, in terms of information disclosure, corporate governance, and firms' performance. We also examined the impacts of important policy changes which aimed to gradually release the segmentation restrictions among these three sub-markets.

For the stock exchanges, we have studied the trading mechanisms and market microstructure of the three China-related exchanges. We compared explicit trading costs and implicit trading costs, wherever applicable, and contrasted them with the costs of the NYSE and NASDAQ. We reported that the explicit costs of China's domestic stock exchanges are not demonstrably higher than that of the Hong Kong stock exchange, yet, the implicit trading costs of two domestic stock exchanges are extremely higher than those of the Hong Kong stock exchange and both the NYSE, and NASDAQ. Further, we compared the market capitalization, the value of trading volume and turnover ratio of the three China-related stock exchanges; we found the domestic stock market has extremely small market size and particularly high turnover ratio, especially when we have to take account of the tradable shares. These findings may give the answers to the questions we asked in the beginning that whether the reason for the Chinese government to list the important SOEs abroad is to gain the benefit of capital raising and more liquid trading. As well as whether the Chinese private firms are more sensitive about the listing costs than the Chinese SOEs so that the private firms choose to register in some tax-free islands before they list in the NASDAQ.

Chapter 3

Literature Review on ADRs and Related Topics

3.1 Introduction

This chapter presents a comprehensive literature review about the main issues about ADRs. In chapter 1, we have explained the reason to select the Chinese ADRs as our research object is because of the special characteristics of the Chinese ADRs that they connect three markets. An explicit connection between the US and Hong Kong market is obvious due to the transmission mechanism between the Chinese ADRs and the underlying H shares. In addition, due to the fact that part of these Chinese ADRs list A shares (only owned by the Chinese citizens) in Shanghai after they list H shares and ADRs (only owned by foreign investors), there is also an implicit connection existing between the China's market and the US and Hong Kong market, such kind of market linkage supplies a closer examination on the available theories and hypotheses put forward in the ADRs literature.

We organize this chapter as: section 3.2 is an introduction about the background of the ADRs; section 3.3 contains an outline of the motivations for cross-listing based on the point of view of the firms; section 3.4 is a literature of the issues related with price discovery hypothesis, the related theories include the segmented market hypothesis and the cost of capital of the cross-listing; section 3.5 is a literature about the ADRs' arbitrage and the limits of the ADRs' arbitrage; section 3.6 reviews the literature of liquidity effect and the liquidity effect on the cross-listed securities; finally, section 3.7 is conclusion.

3.2 American Depository Receipts (ADRs)

An ADR is a negotiable instrument issued by a US depositary bank evidencing ownership of shares in a non-US corporation. Each DR denotes Depositary Shares (DSs) representing a specific number of underlying shares on deposit with a custodian in the issuer's home market. The term 'DR' is commonly used to mean both the physical certificate and the security itself. There are mainly three levels of ADRs based on different accounting standards and Securities and Exchange Commission (SEC) disclosure requirements. The Level I Depositary Receipts are traded in the US Over-The-Counter (OTC) market with prices published in the 'Pink Sheets' and on some exchanges outside the United States. The Level II and Level III Depositary Receipts are exchange-listed securities and traded on NASDAQ, AMEX or NYSE and have more stringent accounting and disclosure requirements.[6]

Prior to 1990, most ADRs were of companies from developed courtiers, such as the UK, Australia, and Japan. However since 1990, more and more firms from emerging countries such as Chile, Mexico, Brazil, India and China have started issuing ADRs and accounted for one third of the total ADRs in circulation at the end of 1990s. Developed country firms have historically used ADRs for overseas listing, but most emerging country firms issue ADRs to raise sufficient capital from the US market (Gande, 1997).

One particular aspect of the ADRs is that the ADR owners can convert the shares into the foreign currency-denominated underlying shares subject to cancellation and conversion fees. By the same token, holders of the underlying shares can convert their shares into ADRs if they are traded in the US markets (Kim et al. 2000). Therefore, an

[6] A detailed introduction on ADRs can refer to the survey paper by Karolyi (1998)

investor who compares the ADR price with the dollar price of the underlying share can get a risk less profit if the price differential is sufficient to cover the transactions costs.

3.3 Firms' motivations for cross listing

The firms' motivations for cross-listing in the literature are straightforward because of the obvious evidence. In conclusion, the motivations of the non-US firms to cross list in the US market are governed by *a)* increased trading liquidity (Mittoo, 1992; Pagano et al., 2002; Rabinovitch et al, 2003); *b)* promoting firms' visibility, exposure, and prestige (Fanto and Karmel, 1997); *c)* reduction in market segmentation and the attendant cost of capital, increase investor recognition, enhance liquidity and bond themselves to protect the minority shareholders (Errunza and Miller, 2003). The above perceptions about overseas listings show that overseas listings should have positive impact on domestic firms' achieving a fair valuation by improving the trading efficiency of their shares listed on the domestic stock exchanges.

3.4 Price discovery process of the ADRs

The literature about the price discovery on the ADRs contains several related theories or hypotheses, which include the segmented markets hypothesis, price discovery theory, and the cost of capital. A prevailing wisdom about the US-listed non-US shares is that cross-listing would decrease the systematic risk of capital caused by segmentation. The segmented markets hypothesis maintains that due to some direct international investment restrictions, such as ownership restrictions and investment barriers are erased by cross-listing in a less-restricted market, the compensation for the local investors’ inability to diversify their investments globally would disappear. So cross-listing would decrease the cost of capital, and ask for a higher equilibrium market price, a lower systematic risk, and thus a lower securities return.

One of the related research questions is in which market price discovery takes place, the home or the off-shore market? Price discovery is defined as the search for an equilibrium price and is a central function of a stock exchange. Researchers find that the shares cross-listed in the integrated markets have different price discovery process with those cross-listed in the segmented markets.

In this section, we review the papers related with the three issues discussed above, the segmented markets hypothesis, the cost of capital, and the price discovery theory. Although some earlier papers we will review in this section are not exclusively about the ADRs, these papers offered empirical study approaches which have been applied later on in the ADRs studies.

3.4.1 The segmented market hypothesis

The study about the international capital markets segmentation and integration starts from Stapleton and Subrahmanyam (1977), Errunza and Losq (1985), and Alexander, Eun, and Janakiramanan (1987). These papers considered a number of investment barriers in the international capital market.

Stapleton and Subrahmanyam (1977) considered two types of segmentations; one is caused by restrictions on certain individuals investing in certain securities and is exemplified by segmentation in international capital markets; and the second one is induced by the simultaneous existence of differential personal tax rates and a fixed element of transactions costs. They built up a Walrasian equilibrium model on the framework of single period capital asset pricing model (CAPM). Their models confirmed the pronounced effect of three financial policies as the firm's intention to remove investment barriers. The three financial policies include Foreign portfolio/direct investment by firms, mergers with foreign firms, and dual listing of the securities of the firm on foreign capital markets. They also confirmed a strong negative tax effect of dividend policy that affect investors' portfolio selection. An investor can gain the advantages of the tax characteristics of the stocks by going long in those that suit his tax bracket and short in those that do not.

Alexander, Eun, and Janakiramanan (1987) considered a situation that one of the domestic securities is dually listed on a foreign capital market, while none of the foreign securities is dually listed on the domestic capital market. The domestic market is assumed to be with relatively limited capital or a relatively underdeveloped capital market and with restriction on its citizens to invest in foreign securities. The scenario of their model was that dual-listing would remove a variety of investment barriers such as transaction costs, information costs, and legal restrictions on domestic investors to invest overseas. Their model clearly indicated that the expected return on the dually listed security was different from its expected return when it is not dually listed. The revaluation of the change in the return after dual-listing depends on the risk premium measured as the relative covariance of the dually listed security with the domestic and foreign market portfolios. Their model predicted that dual-listing would lead to a higher market price and a lower required return due to the decrease in the risk.

Errunza and Losq (1985) proposed ‘Mild Segmentation Hypothesis’ and conducted empirical investigation of the pricing (and portfolio) implications of investment barriers in the context of international capital market. The scenario of their model is partial segmentation that in a two-country capital market where country 1 investors are restricted, country 2 investors are unrestricted. Unrestricted investors can trade in all the securities available; while the restricted investors, can trade only in a subset of the securities, those which are termed eligible. Their hypothesis was the ineligible securities command a ‘super’ risk premium which is proportional to the conditional market risk, and they found supportive though not strong evidence in the less developed countries.

Apart from the segmentation which comprises the direct international barriers caused by regulatory frictions, there are some specific patterns of segmentation which may not be observed directly. For example, Forester and Karolyi (1993) defined ‘industry segmentation’ as industry related segmentation even when two markets share high degree of connection in business, culture and geography such as Canada and the US.

Particularly, with respect to ADRs trading, different trading hours is another important factor of segmentation. The ADRs are in principle fully convertible into their underlying stocks, however in practice these are impossible when the two markets have few overlapping trading hours even when these two markets are integrated according to the prevailing definition. Karolyi (1998) mentioned non-synchronous business and trading hours will increase the costs of information monitoring, which he described as an indirect international barriers. Similarly, Kato et al (1991) and Kim et al. (2000) mentioned the importance to take into account the non-synchronous trading hours in the study of the arbitrage of the ADRs, as which may make arbitrage between ADRs and their underlying shares costly.

3.4.2 The cost of capital

The segmented markets hypothesis is the theoretical background of the issues of the cost of capital and price discovery. As we have discussed in the beginning of this section, there is growing evidence that the cost of capital change around cross-listing date due to the international investment barriers erased, and we will review papers which are specifically within the context of the ADRs. The important papers include Sundaram and Logue (1996), Foerster and Karolyi (1999), and Bekaert and Harvey (2000). Typically, these papers measure the change in systematic market risk (with factor models, such as CAPM and APT), as well as the change in total risk (ex post standard deviations of returns, or ex ante implied volatilities from options) in a specific time period around overseas listing date.

Sundaram and Logue (1996) examined the change of the cost of capital for 76 ADRs from 1982 to 1992, they evaluated three costs: the price-to-book value, price-to-cash-earnings, and price-to-earnings, by adjusting the home and world country industry indices. They found the price ratios increased associated with the cross-border listing, and they attribute the reason as the reducing of the overall effect of segmentation among different markets.

Foerster and Karolyi (1999) studied 153 ADRs from 1976 to 1992, and identified the important changes in the stock return that non-US firms earn cumulative abnormal returns of 19 percent during the year before listing the ADRs, and earn additional 1.20 percent during the listing week, but lose 14 percent during the year following listing. They found supportive evidence for three hypotheses: segmented markets hypothesis, investor recognition hypothesis, and liquidity hypothesis.

Errunza and Miller (2000) presented evidence on liberalization's impact on cost of capital and its relation to the firm's diversification potential, as well as the revaluation effect. Their sample contained the ADRs from 126 stocks from 32 countries over the period 1985-1994. They documented a significant decline of 42% in the cost of capital, as well as positive returns up to and including the announcement of the liberalization (six to one month prior to liberalization and the month of announcement) that are consistent with equity valuations increasing as the cost of capital falls.

3.4.3 The price discovery

Finally, the investigation on price discovery starts from the seminal papers by Hasbrouck (1995), as well as Harris et al. (1995, 2002).

Hasbrouck (1995) addressed the question that for the homogeneous or closely-related stocks traded in multiple markets, in which market the price discovery occurs. He employed an econometric approach that has been largely used in the multi-market trading studies afterwards. The basic idea of this paper is the prices of the same asset in different markets should tend to converge in the long run, while in the short run, these prices may deviate from each other due to trading frictions. He used variance decomposition analysis, and named the components of the variance as 'information share', namely IS model. He found supportive evidence that the preponderance of price discovery take place on the NYSE.

On the other hand, Harris et al. (1995, 2002) used the common factor error correction model to measure how much prices in different markets adjust due to cross-market information flow. They developed their model based on the paper of Engle and Granger (1987), which introduced the concept of error correction that described the cointegrated series move together through time, i.e., given movement away from long-run cointegration equilibrium in one period, a proportion of the disequilibrium is corrected in the next period. So, Harris et al (1995, 2002) conducted the model by employing a vector of *n* component time series to represent a common but exogenous factor of the cointegrated series. The cointegrating vectors define the long-run equilibrium, while the error correction dynamics characterize the price discovery process. They also conducted empirical investigation on the stock IBM based on intraday data, and found consistent findings that the NYSE stands for the predominant market in the function of price discovery during most of the time period.

However, recent empirical studies, reviewed bellow, on the price discovery of non-US firms listed on the NYSE give inconsistent evidence, and the difference may be caused by the links of the domestic and the US markets in terms of trading hours. The markets with non-synchronous trading hours, the markets with several overlapping trading hours, and the markets with entirely overlapping hours have different patterns in the price discovery process.

For instance, Kim et al. (2000) examined the impact of the underlying shares, the exchange rate, and the US market index on the ADRs prices, their sample was composed of 21 Japanese, 21 British, 5 Dutch, 5 Swedish, and 4 Australian firms from the period January 1988 to December 1991. By estimating VAR models and analyzing impulse response functions, they found that the underlying shares appear to be most important, but there is a significant independent role for the exchange rate and the US market index in pricing ADRs. While their paper did not specifically address the question of price discovery, their findings of a role for the US factors suggest a more detailed analysis in terms of the issue of price discovery of the ADRs.

Eun and Sabherwal (2003) studied 62 Canadian firms cross-listed in the US, by applying the error correction model as Harris et al. (1995) and investigating the intraday price for a six-month period, they also performed cross-section regression analysis to study the factors which might attribute to price discovery, such as trading volume in the US, trading costs of the US, and proportion of the shares traded in the US, they reported that for a majority of stocks, price discovery took place in the US, and the greater the proportion of shares traded in the US, the greater the U.S. contribution to price discovery

On the other hand, the studies of the US-listed European stocks tell a different story, since there are only couple of overlapping trading hours between the NYSE and the European stock exchanges. Gramming et al. (2000) examined the intraday data for three US-listed German firms (with three overlapping hours between the NYSE and the Frankfurt Stock Exchange) for three months; they found the Frankfurt Stock Exchange dominated over the NYSE in price discovery only during the three overlapping trading hours. Pascual et al. (2001) examined five Spanish stocks listed in the US by using similar approaches as Gramming et al. (2000), and reported the contribution of the NYSE is less than 3.5%.

Furthermore, for the cross-listed Asian stocks, Kadapakkam et al. (2003) examined 23 Indian Global Depository Receipts (GDRs) which are same in other terms as the ADRs except that the GDRs are listed in London (with three overlapping trading hours between the London and Mumbai stock exchanges), by using the approach as Hasbrouck (1995), they found that both markets contribute equally to the price discovery, and the contributing of the off-shore market to price discovery increase with the foreign ownership and the issue size of the Global Depository Receipts.

In particular, Xu and Fung (2002) studied 10 Chinese ADRs[7] during the time period from January 1994 to May 2000. This paper examined the transmission of pricing information for dual-listed stocks in domestic (Hong Kong) and offshore (the US) markets, and reported Hong Kong had more important role of price discovery than the US.

3.5 Arbitrage opportunity and the limits of arbitrage

The most extensive and attractive research on the ADRs is in the area of determining the existence and extent of the ADRs premium, and the reasons why arbitrageurs are impeded to eliminate the price deviation between the ADRs and their counterparts. An ADR represents the underlying shares (traded in home market) in the foreign (host) market and hence both securities have the same state contingent payoffs. Thus assuming both host and home markets are efficient and integrated, by virtue of the law of one price,

[7] These 10 Chinese ADRs have been included in our sample, except the ADRs have been terminated listing.

the ADRs and their underlying securities should have identical prices after adjusting for the exchange rates. Hence deviations from the law of one price indicate arbitrage opportunities. Arbitrage is a concept central to the theory of capital markets, which is defined as “the act of buying an asset at once price and *simultaneously* selling it or its equivalent at a higher price” (Bodie, Kane and Marcus, 1996:133). Theoretically, it is a “zero-risk and needs zero-net investment strategy that still generates profits” (Bodie, Kane and Marcus, 1996:965). But, in reality, there usually exist some impediments to increase the uncertainty for the arbitrageurs with limited horizons. As we have discussed in the previous section, the literature of the ‘segmented market hypothesis’ has introduced the main factors of international barriers, for instance, the explicit market frictions such as transactions costs, taxes, restriction on regulation etc, as well as the barriers due to the imperfect information which are often implicit and more difficult to observe. In this section, we will review two topics, arbitrage of the ADRs, and the limits of arbitrage of the ADRs which explains why mispricing persists in an extended period.

3.5.1 Arbitrage possibility

The research upon the arbitrage possibility of the ADRs started from Rosenthal (1983), who examined weekly data of 54 stocks from 1974-1978, by testing serial correlation between the ADRs and their underlying shares, Rosenthal found that ADR prices are fairly consistent with weak-form efficiency, as abnormal returns cannot be earned from any price dependence.

Kato et al. (1990) examined daily price difference of the ADRs and their underlying shares from Australia, England, and Japan from 1986 to 1988, and reported that there are no significant differences between the prices of ADRs and that of their respective underlying shares and hence there are no obvious profitable arbitrage opportunities between any of these three markets and the US market. They also run serial correlation test on the return of the ADRs parity, and reported significant but not high correlation.. However these research have some limitations that the statistical tests employed in their papers, such as *t* test and Wilcoxon signed-rank test, are well known as only being sensitive in the location of distribution. Further, the correlation tests employed in these studies cannot uncover a dynamic relationship between two securities, however, it has been recently documented that the correlation between dual-listed stocks changes over time (Karolyi and Stulz, 1996).

Similar findings also include Officer and Hoffmeister (1987), who examined monthly data of 20 NYESE listed ADRs and 25 NASDAQ listed ADRs from 1973 to 1983, and constructed portfolios of ADRs with the domestic stocks, and reported that the ADRs were the substitutes for the underlying shares in terms of diversification effect.

Miller and Morey (1996) chose one UK ADR as objective to study if the markets are efficient in terms of arbitrage opportunities by employing intraday data during the period of March 27 1995 to May 31 1995. The authors calculated the price difference between ADR and the UK share after adjusting for the exchange rate, and reported the mean of the price difference were well within the transaction costs of arbitrage.

However, one exception among those early studies is Wahab et al. (1992), who examined daily return of 31 pairs of the ADRs from eight countries (the UK, Japan, Germany, France, Sweden, Norway, Australia and South Africa) in a time period of 1988 to 1990. They constructed portfolios by two ways, equally weighted and mean-variance weighted, and found limited arbitrage profit ranging between 1.23% and 4.44% by constructing portfolios with mean variance efficient weight, but no profits were found with equally weighted portfolios.

Another important finding is by Rabinovitch et al (2003; they compared distribution of the returns of the ADRs and their underlying shares, among them, six ADRs are from Argentina while fourteen ADRs are from Chile, and their sample time period was from 1993 through 2001. They found that the returns distributions of the Chilean ADRs are significantly different from those of the underlying Chilean shares while the distributions of the returns on the Argentinean ADRs and those of their respective underlying shares are similar. They attributed the difference between Chile and Argentina ADRs to the restrictions on foreign investment as well as a flexible exchange rate in Chile and not Argentina. They hypothesized that transactions costs and market microstructure considerations may explain the differences between returns of ADRs and their underlying securities in some cases, where they exist.

Another interesting recent paper is by Hong and Susmel (2003) who presented significant arbitrage profit by employing pairs-trading in 64 Asian ADRs; they developed ADRs portfolios by taking long-short trading strategy, which is basically to take long position in underlying shares and short in ADRs when the price difference (ADRs price – underlying shares price) is greater than a positive value (depends on the arbitrage cost). The annual arbitrage profit reported in their paper was up to 33%.

3.5.2 The limits of arbitrage

The study on the limits of arbitrage started from the study on the dually-listed company (DLC, also referred to as a Siamese twin[8]), for example, Froot and Dabora (1999), and De Jong et al. (2004).

Froot and Dabora (1999) examined the Anglo-American DLC Smithkline Beecham; they found that significant mispricing in these DLCs has existed over a long period of time. By investigating some fundamental factors, such as the issues related to currency risk, governance structures, legal contracts, as well as the country-specific sentiment, such as the local market behavior, they discovered that fundamental factors cannot explain the price deviations, however the comovement with local stock market indices could explain part of the time-series pattern in the relative returns of the twin stocks.

De Jong et al. (2004) used similar empirical approach as Froot and Dabora (1999) to study 12 DLCs. They also found large deviations from theoretical price parity for all 12 DLCs. And in line with Froot and Dabora (1999), they demonstrated that mispricing can be fairly explained by comovement of the prices of twin stocks with domestic stock market indices. For all DLCs, the relative price of a twin rises (falls) when their domestic market rises (falls). This finding is consistent with the view that noise traders affect the relative pricing of DLCs.

Later on, Gagnon and Karolyi (2004) applied the same methodology to the empirical study on the arbitrage of the ADRs. They also found strong evidence of the price deviations for many of the almost 600 pairs of cross-listed shares from the 39 countries. Their findings supported the results of the previous works in DLCs that mispricing exists due to the comovement with the domestic market indices, however, they in addition found that returns

[8] The two eldest twins are the Anglo-Dutch combinations Royal Dutch/Shell and Unilever NV/PLC. Extensive descriptions of these twins can be found in Rosenthal and Young (1990) and Froot and Dabora (1999)

on cross-listed stocks have significantly higher systematic comovement with the US market index and significantly lower systematic comovement with home market index than their equivalent home-market shares.

The comovement effect indicated in those papers (Froot and Dabora (1999), De Jong et al. (2004), and Gagnon and Karolyi (2004)) can be interpreted as evidence of country-specific sentiment, namely noise trader risk. As Gagnon and Karolyi (2004) have explained in their paper that arbitrageurs are specialized professional portfolio managers, who are risk-averse and concerned about the short-term performance of the fund, while noise traders are idiosyncratic, who act on their erroneous stochastic beliefs. The unpredictability of noise traders' beliefs increase the uncertainty and risk of the expected price of the stocks, so the professional arbitrageurs usually with short horizons would rather wait other than bet against noise traders to put on an arbitrage trade, therefore, which leads the prices to deviate from their fundamental value for an extended period of time.

Apart from the comovement effect, Gagnon and Karolyi (2004) also suggested the trade-based barriers, namely, illiquidity effect is one of other reasons to put off arbitrageurs. Recently, some scholars have applied the theory of liquidity effect developed by Amihud and Mendelson (1986), and O'Hara (2003), to study the liquidity and premium between the cross-listed shares, for instance, Chan et al. (2007), and Guo and Tang (2006).

An explicit evidence of the relation between the ADRs' price premium and liquidity is from one recent paper by Chan et al. (2008). They investigated the cross-sectional relationship between the ADRs premium and the liquidity of the ADRs and that of their underlying shares, their sample consisted of 401 ADRs from 23 countries over the period between January 1981 and December 2003. They employed three liquidity proxies, namely, Amihud Illiquidity[9] (Amihud, 2002), turnover ratio, and trading infrequency. However, they also emphasized their awareness of the difference between liquidity level and liquidity risk, as stated in their paper that "The level of liquidity is the predictable part of the tradability of the security without suffering the adverse consequences of market impact. Liquidity risk, on the other hand, arises from the unpredictable changes in liquidity over time". They only focused on the effect of liquidity level, and reported that the liquidity effects remain strong after controlling for firm size and a number of country characteristics.

Although it is not specifically about the ADRs, another recent paper by Guo and Tang (2006) also gave indirect evidence about liquidity and the return difference. They studied the relation between liquidity and return of the Chinese firms which issued H shares in Hong Kong as well as A shares in Shanghai. Their sample included 29 firms in the period of July 1993 to December 2003. They reported that the liquidity measured by turnover ratio could explain the return difference between two cross-listed shares.

In short, the inconsistent findings in the literature of the ADRs' arbitrage possibility might be due to the different methods and econometric techniques used in those papers. However, it is better to be aware of an obvious trend that the increasing popularity of ADRs are from emerging markets, and we note that the recent studies upon emerging countries are well different from the previous works which were exclusively upon developed markets. Which in addition suggests the arbitrage possibility of the ADRs may tend to exist in the ADRs from emerging markets.

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[9] Amihud (2002) constructed an illiquidity measure which is the average daily return over trading volume

3.6 Literature review on liquidity

Following the literature on the limits of the ADRs' arbitrage that illiquidity effect as the trade-based barriers is one of the possible reasons to hamper arbitrage activity on the ADRs. In this section, we will focus on liquidity with regard to the conceptual terms and dimensions of the liquidity measurements.

3.6.1 What is liquidity

Liquidity is the ability to trade large size quickly, at low cost, when the trader wants to trade. It is the most important characteristic of well-functioning markets. As explained in Harris (2003:394), the liquidity "is the object of a *bilateral search* in which buyers look for sellers and sellers look for buyers" and the efficiency of the *bilateral search* relates to the designs of the market. As stated by Pastor and Stambough (2003) 'liquidity is a broad and elusive concept that generally denotes the ability to trade large quantities quickly, at low cost, and without moving the price.

Amihud et al. (2005) explained that the sources of illiquidity come from *a)* exogenous transaction costs such as brokerage fees, order-processing costs, or transaction taxes; *b)* demand pressure and inventory risk. When the quantity of demand for a stock does not equal to the quantity of supply at certain time, then an agent or market maker may be exposed to the risk of immediately trading or holding the asset in inventory; *c)* private information, which may be the private information about firm's corporate governance, or about order flow; *d)* the difficulty of locating a counterparty that is willing to trade a particular security, or a large quantity of a given security.

3.6.2 How to measure liquidity

Although, the term *liquidity* is not difficult to be understood, it is quite difficult to measure liquidity, as Amihud and Mendelson (1991) posited that liquidity is not directly observable and has a number of aspects all of which cannot be captured in a single measure.

In practice, several liquidity proxies are used and their impact on stock returns has been well documented in the existing academic literature. The earlier empirical studies relate asset returns to different firm specific liquidity measures such as bid-ask spread, illiquidity, turnover, and trading volume. And these papers view liquidity as an effective trading cost to predict the *expected* stock return. For example, *bid-ask spread* by Amihud and Mendelson (1986) and Chalmers and Kadlec (1998); ILLIQ as a measure of *illiquidity* by Amihud (2002); *illiquidity* based on the price response to signed order flow (i.e. using opposite signs for buy and sell orders) by Brennan and Subrahmanyam (1996); *turnover ratio* as the ratio between trading volume and the outstanding shares by Datar et al (1998) and Dey (2005); *trading volume* by Brennan, Chordia, and Subrahmanyam (1998).

The extant liquidity proxies can be classified as four dimensions of liquidity: trading cost, trading quantity or volume, price impact, and trading speed (Liu, 2006). *Bid-ask spread* (Amihud and Mendelson, 1986) is related to trading costs. If a security is less liquid and hence is more costly to trade, then that security should provide a higher gross return as compensation. *Turnover ratio* related with trading quantity or volume supports the predictions of Amihud and Mendelson model (Datar, et al., 1998), but its presence of non-stationary problem and with random component are also found (Dey, 2005). ILLIQ, an *Illiquidity* measure (Amihud, 2002) is calculated as the average of daily ratio of absolute returns to volume, which is exactly the concept of illiquidity, since it quantifies the returns impact based on a given size of trade.

3.6.3 Liquidity risk and liquidity level

There is an increasing attention of the different characteristic between liquidity risk and liquidity level. As concluded by Pastor and Stambaugh (2003), the liquidity measures such as bid-ask spread, illiquidity measurements, and turnover ratio are all related with the marketwide liquidity level, these studies generally find that less liquid stocks have higher average returns. This risk-factor concern started from Amihud et al. (1990), who put forth that liquidity change over time. Amihud et al. (1990) studied the stock market crash of October 19, 1987; they suggested that the crash had down-warded investors' belief about liquidity which had caused a decline in stock price. Their study suggested a dynamic relation between the expected return and liquidity. Amihud (2002) documented the presence of a time-series relation between their measures of market liquidity and expected market returns.

Later on, Pastor and Stambaugh (2003) emphasized the effects of the change of liquidity in terms of time series and cross-section. They found that the covariance between an asset's return and the common liquidity factor ('liquidity betas' as named in their paper) is priced, and the asset prices should reflect a premium for the sensitivity of stock returns to market-wide liquidity: Stocks with greater exposure to market liquidity shocks – i.e., with greater systematic liquidity risk – should earn higher returns.

Similarly, Acharya and Pedersen (2005) expanded the model of Pastor and Stambaugh (2003) by involving four factors capturing both *liquidity level* and *liquidity risk*. They used Amihud ILLIQ (Amihud, 2002) to measure the market wide liquidity level, and employed the 'liquidity betas' (Pastor and Stambaugh, 2003) to measure liquidity risk. They also found that higher (absolute) liquidity related betas lead to higher expected returns.

3.6.4 Trading volume and liquidity risk

Among these different liquidity measurements, trading volume is special and has not been frequently documented in the literature of liquidity level. Karpoff (1987) concluded that in the literature theoretical treatment of trading volume arises in three settings: its relation to the bid-ask spread, its relation to price changes, and its relation to information. The intuition about the trading activity is that it should be easier to trade in more active markets, which then imply a negative relation between trading volume and bid-ask spread. Nevertheless, some recent researches investigated the relation between trading volume and the conventional liquidity *level* proxies at market-wide level, and reported there is little evidence of the association between these measures. For example, Jones (2002) found no significant effect of changes in turnover on changes in bid-ask spreads by applying vector autoregression model to examine the annual data of the Dow Jones 30 industrial stocks in a period of 1900-2000. Similarly, Evans and Lyons (2002) found no association between trading volume and liquidity which is termed as the price impact of trades: trades have more price impact when markets are less liquid, other things equal (this is same as bid-ask spread by nature).

Interestingly, Johnson (2007) found a strong positive contemporaneous relation between trading volume and liquidity risk (measured as the variance of liquidity, same as the definition in Amihud et al. (1990), Pastor and Stambaugh (2003)). He considered a continuous-time economy populated by N_t agents with constant absolute risk aversion (CARA) preferences, where high volume occurs not when there are large changes to the overall state of the economy, but when the mean change in individuals—relative to the average—is high. In his model, volume captures something closer to the physical concept of flux: the total (gross) flow into and out of the population. This, in turn, captures the degree to which the individuals within the population have been rearranged. He concluded that the scale of liquidity innovations—liquidity risk—should be positively related to volume, because intuitively, large changes in liquidity cannot occur without a lot of population flux, and a small amount of flux must imply a small change in liquidity.

3.7 Conclusion

We review three main issues in the literature of the ADRs. First, the motivations to cross list shares is from the point of the firms, since firms' intention to cross-listing is obvious, the research about this issue are relatively few than about the other two issues. Second, the price discovery process is from the point of view of market. Most of the cross-listed stocks are from emerging markets which tend to be segmented. Among a number of segmentation factors, the papers reviewed point to asynchronous trading hours is the most important factor. Price discovery process tends to take place in the US market when the underlying market is with larger over-lapping trading hours with the US. Third, the ADRs' arbitrage is from the point of view of investors. The persistent mispricing arises from gambling activities between the informed traders (arbitrageurs) and the noise traders. Finally, we also review the papers about liquidity effect. In particular, we focus on the difference of several conventional liquidity measurements, and pay attention to the difference of liquidity level and liquidity risk.

From the literature, we also note that the price discovery of the Chinese ADRs has been studied by Xu and Fung (2002). So our objective will be mainly on the issue of the Chinese ADRs' arbitrage.

Chapter 4

Returns Spread and Liquidity of the Chinese ADRs

4.1 Introduction

We are going to perform the main empirical examinations on the Chinese ADRs' arbitrage in chapter 4. From the literature of the ADRs' arbitrage surveyed in chapter 3, we concluded that the investigation on the Chinese ADRs' arbitrage could be processed in two steps. The first examination is to find out whether the Law of One Price (the Law hereafter) exists between the Chinese ADRs and their underlying H shares. The second is to examine the factors which impede arbitrageurs to close price differentials between two securities.

With regard to the first step, according to the Law, if markets are efficient, the ADRs and their underlying shares are supposed to be traded at the same price and very little arbitrage profit would exist between them. However, if the Chinese ADRs are truly traded at same price as their underlying H shares adjusted for the exchange rate, then it would be difficult to explain some remarkable market phenomena that we have quite often observed; that hedge funds are among the top 10 shareholders of these Chinese ADRs. Given the nature of the hedge funds, this practical evidence clearly suggests the existence of deviation between the prices of these two identical securities and implied a possible arbitrage profit.

On closer examination of the papers on the ADRs' arbitrage possibility, we noticed the findings of these papers are inconsistent, which we believe is due to different methodologies applied. Some earlier papers employ basic statistical tests such as t-test and Wilcoxon signed-rank test which are only sensitive to location, as well as correlation tests to compare the returns of the ADRs and the underlying shares. These papers report no significant differences exist between home and host securities' prices, and thus conclude that very few profitable arbitrage opportunities persist between any of the home markets and the US market (see Kato et al (1991), Miller and Morey (1996), and Karolyi and Stulz (1996)). On the other hand, Wahab et al (1992) used portfolio approach and found small but significant differences between prices of some ADRs and their underlying securities. Furthermore, Rabinovitch et al (2003) employed non-parametric methods to compare return distribution of the ADRs and their underlying shares; they found that even when the means and medians are not different there may still be differences in higher moments for securities return distributions.

In this chapter, we will use both standard location tests as Kato et al (1991), Miller and Morey (1996), and Karolyi and Stulz (1996), as well as non-parametric tests to compare return distribution as Rabinovitch et al (2003).

In the literature on financial markets, the distributions of returns of the cross-listed securities have long been the subject of researches for the Law. In particular, the distributions of the returns of ADRs and their underlying shares are compared to test the implications of the Law in recent published papers. Due to the fact that 'there is ample empirical evidence that the distribution of short-term security returns, e.g., daily, weekly or monthly, is non-normal' (Campbell, Lo and MacKinlay, 1997), return distribution studies pay attention to the higher moments especially on skewness and kurtosis, instead of on the lower moment such as mean. Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A normal distribution is symmetric of the centre point.

Kurtosis is a measure of whether the data are peaked or flat relative to a normal distribution. Data set with high kurtosis tend to have a distinct peak near the mean, decline rather rapidly, and have heavy tails. Data set with low kurtosis tend to have a flat top near the mean rather than a sharp peak. The deviation from normal distribution in the higher moments leads to newly developed financial analysis methods and portfolio studies, for example, the Copula weighted portfolio which is based on the tail dependence between markets and risk factors. This approach applies widely in the researches of hedge funds strategy and the comovement between market indices. Although the portfolio approach motivates us to carry out the return distributions study, it will not be discussed in this thesis because of the limitation of time and we leave it for further extension in future.

With respect to the second step, we will follow the approach of Gagnon and Karolyi (2004). This paper not only reported evidence of existence of significant mispricing in the ADRs, but also specified the various cross-sectional attributes at the country-, industry- and firm-level. They further grouped these attributes into three major categories of barriers or frictions: *market-based, information-based, and trading-based*. Market-based barriers can include direct and indirect investment barriers faced by the foreigners, which address the question about the segmented market hypothesis. Information-based barriers are the asymmetric information about noise trader risk across the host and home market as well as the asymmetric information between corporate insiders and other shareholders, which hamper professional arbitrageurs to bet against noise trader, so the mispricing would be persistent for an extended period. Trading-based barriers are the illiquidity in the home market for the underlying shares or in the US market for the ADRs, since the ADRs are usually not frequently traded, arbitrage activity may be impeded for the fear of illiquidity.

In particular, we test the information-based and the trade-based barriers on the limit of the ADRs' arbitrage. These two barriers are examined as 'comovement effect' and 'illiquidity effect' in the paper of Gagnon and Karolyi (2004). According to Froot and Dabora (1999), De Jong et al. (2004), and Gagnon and Karolyi (2004), the comovement effect arises due to the noise trader risks. Noise traders tend to move with the local market, so the noise trader risks would have different extent and are usually asynchronous in the host and home markets. The professional arbitrageurs who are usually with limited horizons would not be able to remove the mispricing for fear of the noise trader risk. As a result, the mispricing can be persistent over long period.

Apart from the comovement effect, we further test the illiquidity effect. Gagnon and Karolyi (2004) provided evidence that the greater the illiquidity in one or the other or both markets, the greater the net market risk exposures revealed for the return differences between the ADRs and the underlying shares. In addition, as analyzed in chapter 2, we introduce the market microstructure and trading mechanisms of the three China-related exchanges, and compare the trading mechanisms and the trading costs of these three exchanges with that of the NYSE and NASDAQ. We find that the size of the Shanghai and Shenzhen stock exchange is extremely small compare to that of the Hong Kong stock exchange as well as to that of the NYSE and NASDAQ. A large stock exchange tends to provide bigger width and depth, and therefore greater liquidity. Second, we show that due to the employment of different trading mechanisms, a notable difference among these stock exchanges is whether the market makers exist. The NYSE and NASDAQ are dealer market and all transaction must be processed by the market makers, the Shanghai and Shenzhen stock exchanges are auction markets where no market makers exist; all transaction are cleared through electronic trading system, and the Hong Kong stock exchange though has a small number of market makers, it is designed as an auction market and all transactions are carried out through electronic trading system, the market makers in the Hong Kong stock exchange will supply liquidity only on very particular situations, but not be involved in the daily frequent exchanges. Market makers not only play a critical role in providing liquidity, some of the market makers or dealers also take part in block trades. Block trades account for about 50% of the daily trading value in the US equity markets, however, there are nearly no block trade in Hong Kong or Shanghai stock exchanges. In conclusion, we suspect that liquidity is also one of the important attributes of the ADRs' mispricing.

Finally, we have introduced the market liberalization of China's stock market in chapter 2, and we have explained that the distinctive characteristic of the Chinese ADRs is due to the fact that they connect three markets, the US, Hong Kong, and China's stock markets. We view the important reforms of the China's stock market as the innovation, and try to find if the market innovations would have any impact on the Chinese ADRs' price. So we process to test for the effects of structural change on the comovement effect.

The chapter proceeds as follows: section 4.2 contains an introduction the Chinese ADRs; section 4.3 explains the hypothesis and methodology; section 4.4 provides a description of the data; section 4.5 is the empirical results of tests; section 4.6 concludes.

4.2 Overview of the Chinese American Depository Receipts (ADRs)

By the end of 2006, 59 Chinese firms have accessed the US markets by issuing ADRs. Among those, 16 are listed on the NYSE, 17 on the NASDAQ, and 26 on the OTC market. China's first overseas IPO, Brilliance China Automotive (CBA) was listed on the New York Stock Exchange (NYSE) on October 1992 and raised US$ 80 million.

The 59 Chinese ADRs have some interesting features; the 16 firms listed on the NYSE are all SOEs with monopoly power in the domestic market; they operate in some critical industries, such as electric power, petroleum, airline, and telecom. These companies first issue H shares and then make the H shares serve as backing for their ADR programs, where the receipts are potentially convertible into the underlying H shares, (except for Huaneng Power Intel (HNP) and Brilliance China Automotive (CBA), which issue IPO on the NYSE before issue H shares in Hong Kong, and then combine ADRs with their H shares instead of existing shares in the US). The 17 firms listed on the NASDAQ are all young privately owned IT companies, these firms do not issue H shares in Hong Kong, and they first issue IPOs on the NASDAQ, then convert part of the IPOs to ADRs. The 26 firms on the OTC market have different characteristic, they are also SOEs but do not enjoy a monopoly position. Finally, in the OTC market, 11 firms have H shares as underlying shares, 6 firms have B-shares as underlying shares, and 9 firms have underlying shares issued in the US.

One interesting thing deserving our attention is to look at how the Chinese NASDAQ-listed firms enlist abroad. First, the timing of Chinese IT firms to list on the NASDAQ is related with the 'NASDAQ surge', the first 'surge' is around 1999, however the Chinese IT industry just started since then, computer owners and internet users were still very few in 1999, the second 'surge' started from 2003 in NASDAQ, and provided good opportunities for the well-developed Chinese IT firms. Second, the manner of these Chinese IT firms listing abroad is entirely different from those listed on the NYSE. *a)* All of these firms in NASDAQ are private, so they don't have support from the government. *b)* These firms have smaller shareholder base and market capitalization, which make most of them ineligible to list in Hong Kong. *c)* Most of these firms merge with a shell company in the US, and register in the free-tax heavens such as Bermuda, Cayman Islands before their listing on NASDAQ. This way of listing continued until 2005 when China's government issued regulations to ban Chinese private firms to list abroad in this way and as a result of which, all the Chinese NASDAQ listed firms have close listing dates between 2003 and 2005.

4.3 Research Methodology and Hypothesis Development

4.3.1 To test the law of one price

The objective of this chapter is to examine the arbitrage possibility between the 15 NYSE-listed Chinese ADRs and their underlying H shares, and if there are any price deviations, we will additionally measure these price differentials taking into consideration the impact of the market factors and the liquidity risk.

As the literature survey on the ADRs arbitrage in chapter 3 has indicated that the location tests such as t-test and Wilcoxon signed-rank test tend to uncover an equality relation between the price parity and suggest that the law of one price exists between two securities, while the Kolmogorov-Smirnov test, which is well-known for its sensitive to both the location and shape of a distribution, tend to reveal the difference in the distribution, for instance, the difference in skewness and kurtosis. And we have discussed the importance to be aware of the distribution difference in the introduction of this chapter. Therefore, we will use both the approaches of Rabinovitch et al. (2003) and that of Kato et al. (1990) to test the law of one price. We will apply t-test, Wilcoxon signed-rank test, Kolmogorov-Smirnov test, and the parametric joint test of simultaneous means and variance equality[10]. Our null hypothesis is; there is no difference in the return distribution of two securities, and the alternative hypothesis is of the opposite.

4.3.2 To test the comovement effect on mispricing

Secondly, as reviewed in chapter 3, the literature of segmented markets suggests several possible international barriers that may influence how securities are priced in their respective market, for example, restrictions on foreign ownership, tax, illiquidity, non-synchronicity, etc. With regard to the Chinese ADRs, the underlying market is Hong Kong which is a free market as the US market without restrictions on foreign investors; so we expect investors in the two markets could freely buy or sell shares in both the domestic and cross-border markets. On the other hand, Hong Kong has pegged its exchange rate with the US dollar since 1983, so the international traders would expose to zero risk in exchange rate. The critical factor in the Chinese ADRs' trading is the non-synchronous trading hours between the US and Hong Kong market. The 12-hour's

[10] The original test method can be found in Bradly and Blackwood (1989). "A simultaneous test for means and variances". *Am. Statistician* 43,234-235

difference between the two markets induces non-overlapping trading in two markets. In chapter 3, the comovement effect suggests securities tend to systematically move with the local market index, and Gagnon and Karolyi (2004) showed the ADRs have a higher systematic comovement with the US market index than the comovement with the home market.

Therefore, we develop our testing in two steps: first, we follow Kato et al. (1991) who applied correlation test on the returns of the ADRs and their underlying shares, and reported significant correlation between two securities with regard to both contemporaneous and lead-lag relation; and they concluded that the US and the home market are weak-form efficient and integrated fully, there exists no arbitrage possibility. We will employ Spearman correlation test and Pearson correlation test to examine the returns of the Chinese ADRs and the underlying H shares.

Second, we follow De Jong et al. (2003) and Gagnon and Karolyi (2004) to examine the comovement effect of two securities. The implication of the comovement effect is that the ADRs (the underlying H shares) tend to move more closely with the US (Hong Kong) market index than Hong Kong (the US) market index. Because if the ADRs (the H shares) move with local and off-shore market equally, then the noise trader in the US (Hong Kong) market would not create different risk of the price of the securities to deter the arbitrageurs. Further, by reason of the asynchronous trading hours, it is difficult to tell whether mispricing exists if we exclusively focus on contemporaneous relation. Likewise, arbitrage may not remove mispricing within one day because of the time needed to complete the necessary trades. Especially, the US market opens 12 hours later than Hong Kong, so the Hong Kong market index at day *t* may be reflected by the US market index at day *t+1*, so we consider the comovement effect in the longer horizon; we take the first stage time series regression model as De Jong et al. (2003) and Gagnon and Karolyi (2004) and give our model as bellow:

$$r_t^{ADR} - r_t^{HK} = \alpha^{US} + \sum_{i=-2}^{0} \beta_i^{US} R_{t+i}^{US} + \sum_{i=-2}^{0} \beta_i^{HK} R_{t+i}^{HK} + \varepsilon_t \quad \ldots\ldots (1)$$

Where r_t^i refers to the returns for security *i* (H share or ADR) on day *t*, ($r_t^{ADR} - r_t^{HK}$) is the return spread between two securities at day *t*. We calculate the continuously-compounded return as ($ln\ (P_t/P_{t-1})$). R_t^{US} is the return on the US (host) market on day *t*, R_t^{HK} is the return on Hong Kong (underlying) market on day *t*.

Further, some of those Chinese ADRs are also subsequently listed on the Shanghai Stock Exchange (SHSE). The shares listed on the Stock Exchange of Hong Kong (SEHK) are H shares, which allow foreign ownership and are traded in Hong Kong currency while the shares listed on SHSE are A shares available only to the Chinese citizens and traded in Chinese currency. And in chapter 2, we have discussed that there is strict restriction on the ownership of A shares as well as the limitation for the Chinese citizens to own foreign currency, given that H shares must be traded at Hong Kong currency, that stops any arbitrage possibility between H shares and A shares, even as we have introduced in chapter 2 that a huge price discount exists between A shares and H shares.

For the ADRs have A shares in Shanghai stock exchange, we also include Shanghai market returns as an explanatory variable in spite of the evidence that the Chinese market and the global market in general and the US market in particular are not correlated. Yet, Shanghai market may have an indirect impact on the Chinese ADR returns through Hong Kong market. This is because some of our empirical evidence suggests an inverse correlation (negatively related) between the market returns of Hong Kong and Shanghai. While the correlation is expected, the inverse correlation is surprising given that the markets in Hong Kong and Mainland China are integrated due to their common culture, interdependence, and cooperation in business. They also have 7 overlapping opening hours of stock exchanges during which political and economic news in China are likely to impact H shares' performance in Hong Kong, which may then transmit from the H shares to the ADRs in US due to the integration between US and Hong Kong markets. A possible explanation for the inverse correlation is that Hong Kong and Shanghai markets compete for funds and thus one market can gain only at the cost of the other.

Our null hypothesis is that if two markets are weak form efficient and fully integrated, then the differential of the returns of two securities is zero. So the coefficient of the US and Hong Kong market indices should be zero. Therefore, the alternative hypothesis is that if the two markets are segmented, then market shocks can explain movements in the return differential, the return differential is positively affected by a positive shock in the US market index and negatively affected by a positive shock in the Hong Kong market index.

4.3.3 To test the liquidity effect on mispricing

As discussed in chapter 3, along with Karolyi (1998), De Jong et al. (2003), Gagnon and Karolyi (2004), etc., several theoretical and empirical studies have examined the mispricing of the paired traded stocks, and have carried out investigations on the issues related with market imperfections, limits to arbitrage, noise trader risk, or a combination of these arguments. Although quite a few papers have argued that the illiquidity across markets could be one of the attributes to the mispricing, it is not until recently did researchers begin a rigorous study of whether a difference in liquidity (DIL) between markets explains part of this phenomenon. The strong evidence of the liquidity effect on the ADRs mispricing are given by Chan et al. (2008), who argued when similar securities are traded at different prices at different markets, the liquidity or illiquidity in these markets also differ in the direction, for example, a rise of the liquidity (illiquidity) in the US market will lead to a decrease (increase) on the ADRs price differentials, likewise, a rise of the liquidity (illiquidity) in the underlying market will lead to a increase (decrease) on the ADRs price differentials. Their results clearly support the illiquidity effect as concluded in Gagnon and Karolyi (2004).

As we have pointed out in chapter 3 that it is crucial to select proper liquidity measures from a full range of liquidity proxy candidates. The simplest and the most traditional illiquidity measure is the bid-ask spread calculated by Amihud and Mendelson (1986), this proxy has been widely used in empirical researches. Unfortunately, it is difficult to apply the bid-ask spread in our thesis due to constraints on data availability. Bid-ask spread need to use intra-day data, although intra-day data on transactions and quotes are available for the ADR market in the US, it is not available for the H shares. As a result, we have to use alternative liquidity measures that use only daily return and volume data as inputs.

Same as Chan et al. (2008), we decide to use ILLIQ (Amihud, 2002) as the illiquidity measure. ILLIQ is defined as the average of daily ratio of volume to absolute return, the merit of this measure is that ‘it measures the daily price impact of the order flow, which is exactly the concept of illiquidity, since it quantifies the price/return response to a given size of trade’ (Chan et al., 2008). Therefore, we calculate daily ILLIQ as:

$$ILLIQ_t = \frac{|r_t|}{vol_t}$$

Where $ILLIQ_t$ is the daily illiquidity proxy, $|r_t|$ is the absolute value of return at day *t*, vol_t is the trading volume at day *t*.

Chan et al. (2008) also employed turnover ratio as alternative liquidity measure. Turnover ratio is calculated by the traded volume divided by the total outstanding shares, it measures how actively the stock is traded. However, given the specific characteristic about the Chinese ADRs that the Chinese ADRs are backed by the H shares, these ADRs firms issued H shares in Hong Kong and then sold small part of H shares as the ADRs in the US market, then the turnover ratio, the relative ratio between traded shares and outstanding shares, will not be able to tell if the ADRs is traded more actively than the H shares, because most part of the floating shares will remain in the Hong Kong market. As a result, we decide to choose trading volume as one of our liquidity measures; we view trading volume as a proxy capturing liquidity risk.

As we have discussed in chapter 3, in the literature of liquidity, it is important to be aware of the difference of two liquidity dimensions: the liquidity level and the liquidity risk. The level of liquidity is the *predictable* part of the tradability of the security without suffering the adverse consequences of market impact. Liquidity risk, on the other hand, arises from the *unpredictable* changes in liquidity over time. Johnson (2007) demonstrated that the scale of liquidity innovations (liquidity risk) is positively related to volume, because intuitively, large changes in liquidity cannot occur without high trading volume, and a small amount of trading volume must imply a small change in liquidity. Therefore, we use trading volume as alternative measure of liquidity *risk*, and we give our model as below:

$$r_t^{ADR} - r_t^{HK} = \alpha + \beta_1^{ADR} ILLIQ_t^{ADR} + \beta_2^{HK} ILLIQ_t^{HK} + \varepsilon \qquad (2)$$

$$r_t^{ADR} - r_t^{HK} = \alpha + \beta_3^{ADR} liq_t^{ADR} + \beta_4^{HK} liq_t^{HK} + \varepsilon \qquad (3)$$

Where r_t^{ADR} and r_t^{HK} are the return at day t, $ILLIQ_t$ is the proxy measuring illiquidity for ADRs and H shares at day t, liq_t is calculated by the logarithms of trading volume at day t for ADRs and H shares.

Equations (2) and (3) aim to capture whether the exposure to the illiquidity and liquidity risk would impact on the return differentials. Our null hypothesis is mispricing between the ADR and H share is zero, therefore, the *beta* of each the liquidity proxies equal to zero. The alternative hypothesis is β_1^{ADR} is positive while β_2^{HK} is negative, because the positive illiquidity-return relation. And β_3^{ADR} is positive and β_4^{ADR} is negative, because high liquidity risk should lead to high return.

4.4 Data and descriptive statistics

4.4.1 Data

Our sample of the Chinese ADRs is drawn from the Bank of New York's Complete DR Directory, which is available on the web (www.adrbny.com). This directory provides the issuer name, symbol, CUSIP number, listing market (Rule 144A, AMEX, NASDAQ, or NYSE), ADR bundling ratio, home country, industry, region, and the name of the sponsoring bank if the issue is sponsored. The information about the listing history of the H shares is drawn from the website of Hong Kong stock exchange. Our sample includes 15 pairs of NYSE-listed ADRs and H shares, the sample period varies depends on individual stocks, the longest is of SHI (SINOPEC Shanghai Petrochemical Company LTD) which begins on October 1993, the shortest period is of CEO (CNOOC China National Offshore Oil Co.) which begins on April 2004, the sample period for all ADRs and H shares end on October 2006. We obtain daily close price after adjusted with dividends, trading volume and market indices from DataStream Advance 4.0.

As of October 2006, there are 33 Chinese ADRs (ADR level III) listed on the US stock exchanges; another 26 (ADR level I) are traded on the OTC. Among the exchange listed ADRs, 16 are listed on the NYSE and 17 on the NASDAQ. For the purpose of this study, we are specifically focusing on the NYSE-listed ADRs since we aim to test the arbitrage possibility. We further exclude one NYSE-listed ADR, namely STP, due to this ADR was listed on Dec of 2005 and its time period is less than one year up to our sample ending date. We exclude the ADRs listed in NASDAQ, because these ADRs do not have underlying shares in the stock exchange other than NASDAQ, we also exclude the ADRs listed in OTC, because these ADRs cannot provide the examination on the comovement effect due to the inability of a proper market index. We then group 15 ADRs into two portfolios: Portfolio I consists of 9 stocks listed on the NYSE with underlying shares in Hong Kong stock exchange; Portfolio II consists of 6 stocks listed on the NYSE with H shares in Hong Kong stock exchange, and A shares in Shanghai stock exchange.

Table 4.1 overview of the Chinese ADRs listed on the NYSE and NASDAQ as of October 2006

NYSE listed Chinese ADRs										
Company name	**ADR Symbol**	**Listing Date**	**HK Underlying Shares**	**HK Listing Date**	**SH Home Shares**	**SH Listing Date**	**Industry**	**Conversion Ratio**	**Average price ($)**	**Average trading volume ($)**
CHINA EASTERN AIRLINES CORPORATION LIMITED	CEA	01/97	0670	01/97	600115	11/97	Travel & Leisure	100	14.673	18815.97
CHINA PETROLEUM & CHEMICAL CORPORATION	SNP	10/00	0386	10/00	600028	08/01	Oil& Gas Producers	100	31.624	172664.7
CHINA SOUTHERN AIRLINES CO., LTD.	ZNH	04/98	1055	04/98	600029	07/03	Travel & Leisure	50	13.772	19490.58
HUANENG POWER INTERNATIONAL, INC.	HNP	10/94	0902	01/98	600011	12/01	Electricity	40	27.247	182012.3
SINOPEC SHANGHAI PETROCHEMICAL COMPANY LIMITED	SHI	07/93	0338	07/93	600688	11/93	Chemicals	100	23.795	34844.11
YANZHOU COAL MINING COMPANY LIMITED	YZC	04/98	1171	07/98	600188	07/98	Mining	50	28.488	19703.85
ALUMINUM CORPORATION OF CHINA LIMITED	ACH	12/01	2600	12/01	N/A	N/A	Industrial Metals	25	11.396	328227.8
BRILLIANCE CHINA AUTOMOTIVE HOLDINGS LIMITED	CBA	10/92	1114	10/99	N/A	N/A	Cars & Parts	100	22.263	32509.74
CHINA LIFE INSURANCE COMPANY LIMITED	LFC	12/03	2628	12/03	N/A	N/A	Life Insurance	40	36.137	431115.6
CHINA MOBILE (HONG KONG) LIMITED	CHL	10/97	0941	10/97	N/A	N/A	Mobile Telecom	5	17.744	441852.4
CHINA TELECOM CORPORATION LIMITED	CHA	12/02	0728	11/02	N/A	N/A	Fixed Line Telecom	100	32.181	123691.6
CHINA UNICOM LIMITED	CHU	06/00	0762	06/00	N/A	N/A	Mobile Telecom.	10	10.117	444997.7
CNOOC - CHINA NATIONAL OFFSHORE OIL CORP	CEO	02/01	0883	04/04	N/A	N/A	Oil& Gas Producers	100	63.293	116834.8
GUANGEN RAILWAY COMPANY LIMITED	GSH	05/96	0525	05/96	N/A	N/A	Travel & Leisure	50	10.690	32218.42
PETROCHINA COMPANY LIMITED	PTR	03/00	0857	04/00	N/A	N/A	Oil& Gas Producers	100	41.025	318396.9

NASDAQ listed Chinese ADRs										
51JOB, INC.	JOBS	10/04	N/A	N/A	N/A	N/A	IT	2	19.345	261758.3
BAIDU.COM, INC.	BIDU	08/05	N/A	N/A	N/A	N/A	IT	1	79.606	2250077
CHINA FINANCE ONLINE CO., LTD.	JRJC	10/04	N/A	N/A	N/A	N/A	IT	5	6.510	139716.3
CHINA MEDICAL TECHNOLOGIES	CMED	08/05	N/A	N/A	N/A	N/A	IT	10	25.874	654057.1
CHINA TECHFAITH WIRELESS COMMUNICATION LIMITED	CNTF	05/05	N/A	N/A	N/A	N/A	IT	15	12.607	345958.1
CTRIP.COM INTERNATIONAL, LTD.	CTRP	12/03	N/A	N/A	N/A	N/A	IT	2	30.091	418166.5
ELONG, INC.	LONG	11/04	N/A	N/A	N/A	N/A	IT	10	13.096	150726.6
FOCUS MEDIA HOLDING LIMITED	FMCN	07/05	N/A	N/A	N/A	N/A	IT	10	49.560	583140
HURRAY! HOLDING COMPANY LTD.	HRAY	02/05	N/A	N/A	N/A	N/A	IT	100	8.067	129041.6
LINKTONE LTD.	LTON	03/04	N/A	N/A	N/A	N/A	IT	10	7.976	329068.5
NETEASE.COM, INC.	NTES	06/00	N/A	N/A	N/A	N/A	IT	100	8.702	3648606
NINETOWNS DIGITAL WORLD TRADE HOLDINGS LIMITED	NINE	12/04	N/A	N/A	N/A	N/A	IT	1	6.142	226728
SHANDA INTERACTIVE ENTERTAINMENT LIMITED	SNDA	05/04	N/A	N/A	N/A	N/A	IT	2	23.274	1000400
THE9 LIMITED	NCTY	12/04	N/A	N/A	N/A	N/A	IT	1	22.577	259323.7

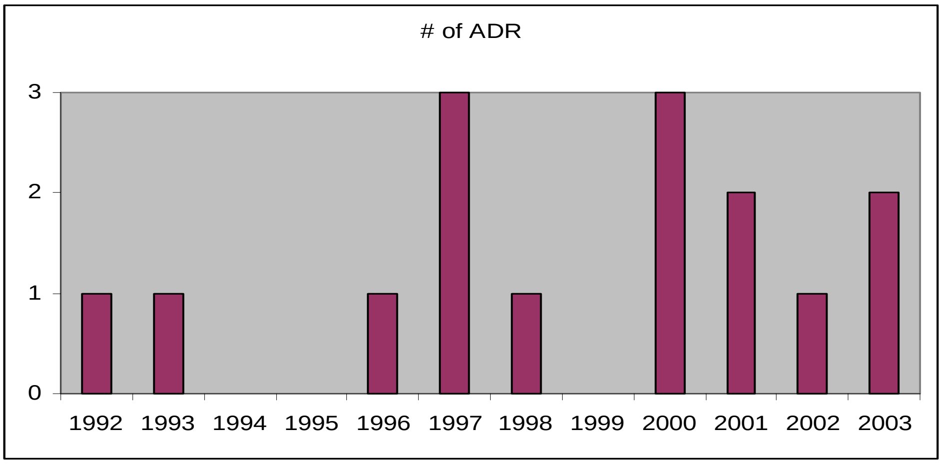
1. STP, ACTS, VIMC are excluded from our empirical study, because their effective date is after Oct 2005, the time period is not enough for one year.
2. The conversion ratio indicates the number of underlying shares in Hong Kong that corresponds to one ADR share in New York, and this number is of October 2006.
3. In order to compare returns from different markets, the sample period for each firm starts on the listing date of ADR or H shares of the company, whichever is later.

Table 4.1 contains an overview of the Chinese ADRs listed on NYSE and NASDAQ, the corresponding underlying securities, if available on Hong Kong (SEHK) and additional listing on Shanghai (SHSE) stock exchanges along with the respective listing month and year in each exchange. We observe that the listing, month and year and particularly the years in which the ADRs were issued reveal some strategic decisions on the part of the issuing Hong Kong firms to enlist their ADRs.

4.4.2 The Chinese ADRs listing history and listing pattern

We summarize the NYSE-listed Chinese ADRs listing history in the following Graph 4.1.

Graph 4.1: Yearly ADR listing by Hong Kong firms during the sample period.



First, as Graph 4.1 indicates, the Chinese ADRs listing during our sample period do not show any trend or any other discernible regularity; strikingly though, more than 50% (8/15) ADRs were listed between 2000 and 2003. A reasonable hypothesis for this structural shift in 2000 may be the market collapse in US, particularly the IPO market, which led some Hong Kong firms[11] to offer their securities to the US investors as alternative investment options.

Second, as we have mentioned in the introduction of this chapter, we aim to investigate the impacts from a set of reforms happened in China's domestic stock market around 2003. Since part of these NYSE-listed ADRs additionally listed A shares in Shanghai stock exchange after they sequentially listed in the Hong Kong stock exchange and the NYSE. Given the close relation between Hong Kong and China, we expect that China's stock market would have some indirect impacts on these ADRs through her connection with Hong Kong. Therefore, we will later use 2000 and 2003 as our two structural shift points for regression analysis.

We also notice that some interesting listing behavior exist in these ADRs. First, almost all listings on the Hong Kong market and on the NYSE were done almost simultaneously (within a month) for all the ADRs, and predate listing on the Shanghai market for the ADRs with A shares listed in Shanghai[12]. The question about these firms' motivation to list A shares in Shanghai is worth our concern. While the motivation behind the Hong Kong firms to cross list in the US to attract more capital is obvious, the implications for these firms to cross-list in Shanghai stock market is not clear. According to our research on the trading costs and market conditions in chapter 2, we know the Shanghai stock exchange has far less liquidity, depth, and width than that of Hong Kong. Then it seems to contradict the conventional wisdom that firms' cross-listing is to achieve

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[11] For the purpose of this study, we name these Chinese firms as Hong Kong firms to differ them from the Chinese firms without issuing H shares, because they issue IPO on the SEHK, and behave more like Hong Kong firms rather than Chinese mainland firms, the details are discussed in chapter 2.

[12] HNP is an exception that issued H shares in 1998, A shares in 2001, and ADR in 2003. This order of listing for all securities except HNP i.e., listing as ADRs prior to or simultaneously on Hong Kong exchange prevents us from investigating the announcement effect around cross listing.

lower cost of capital and greater liquidity. Further it raises questions about those Chinese ADRs which do not list A shares in Shanghai, and those NASDAQ-listed ADRs which do not list in any of their home country exchanges. The answer may lie in the ownership structure of firms since the firms with additional cross listing in Shanghai are SOEs with strong political ties with the Chinese government.

In table 4.1 above, we also list the corresponding industries which these firms belong to. We find that all NYSE-listed ADRs belong to four industries - utilities, communication, travel and leisure, and heavy engineering and industrial products. The industry distribution for the NASDAQ ADRs is different; they are all young IT firms. Compared to the large industrial base of China, the ADRs from China seem to be from a very selective industry core. Table 4.2 gives the overall distribution of all Chinese listed firms in domestic stock market as of 2006.

Table 4.2 Overview of the Chinese listed firms' industry distribution (2006)

Industry	No.	Industry	No.
Agriculture, Forestry, Fishing and Hunting	38	Mining	25
Food, Beverage	61	Textile, Appeal, Leather	68
Wood Product	4	Paper, printing	30
Petroleum, Chemical Product, Plastics, Rubber	153	Electrical Equipment	51
Metal, Non-metallic Mineral product	130	Machinery, Equipment, Meter	227
Medicine, Biologic product	91	Other manufacturing	20
Electricity, Gas, Water supply	62	Construction	31
Transport, Storage	63	Information, Technology	90
Wholesale and Retail Trade	92	Finance, Insurance	12
Real Estate	55	Social Services	42
Transmission, Culture	10	Conglomerate	78

Total listed firms: 1433
Source: 2006 Yearbook from http://www.csrc.gov.cn

4.4.3 Descriptive statistics on ADRs and H shares returns

We compute continuously compounded returns on the ADR listings in US exchanges and their corresponding underlying stocks listed in the Hong Kong Stock Exchange (and Shanghai Stock Exchange as applicable) as $r_t^i = \ln(P_t^i / P_{t-1}^i)$ where P_t^i denotes adjusted closing price of security *i* on day *t*. The sample period for each pair of ADR and the underlying security begins from the latest listing dates of the ADR or HK security[13] and ends in October 2006 and the actual number of observations for each security used in our analysis is reported in Table 4.3.

Table 4.3: Descriptive statistics on daily returns r_t^{ADR} and r_t^{HK}

Symbol	Obs.	Mean	Std. Dev	Min	Max	Skewness	Kurtosis
Portfolio I							
ACH [2600.hk]	1187 1226	0.116% (0.107%)	2.99% (3.14%)	-0.104 (-0.149)	0.162 (0.144)	0.331 (0.098)	4.550 (4.358)
CBA [1114.hk]	1274 1301	0.009% (0.010%)	3.08% (3.63%)	-0.248 (-0.219)	0.175 (0.221)	0.229 (0.285)	6.619 (7.743)
LFC [2628.hk]	715 736	0.185% (0.178%)	2.26% (2.09%)	-0.104 (-0.081)	0.115 (0.099)	0.203 (0.199)	6.586 (5.722)
CHL [0941.hk]	2827 2774	0.073% (0.078%)	2.93% (2.76%)	-0.157 (-0.165)	0.186 (0.156)	0.297 (0.253)	6.672 (7.076)
CHA [0728.hk]	970 1005	0.083% (0.074%)	1.93% (1.89%)	-0.087 (-0.083)	0.082 (0.075)	0.153 (-0.017)	4.698 (4.273)
CEO [0883.hk]	645 667	0.118% (0.113%)	1.89% (1.94%)	(-0.075) (-0.077)	0.087 (0.090)	0.199 (0.059)	4.222 (4.351)
GSH [0525.hk]	2620 2595	0.035% (0.010%)	2.88% (3.09%)	-0.207 (-0.203)	0.268 (0.185)	0.556 (0.002)	10.641 (7.680)
PTR [0857.hk]	1588 1542	0.130% (0.136%)	2.03% (2.03%)	-0.092 (-0.107)	0.112 (0.099)	0.1274 (0.155)	5.848 (5.340)
CHU [0762.hk]	1587 1650	-0.053% (-0.042%)	2.82% (2.67%)	-0.128 (-0.131)	0.159 (0.143)	0.227 (0.078)	6.255 (5.338)
Portfolio II							
CEA [0670.hk]	2432 2405	-0.002% (-0.006%)	3.32% (3.94%)	-0.194 (-0.375)	0.236 (0.267)	0.706 (0.225)	8.812 (10.196)
SNP [0386.hk]	1504 1560	0.072% (0.095%)	2.45% (2.37%)	-0.169 (-0.090)	0.182 (0.104)	0.080 (-0.063)	8.334 (4.248)
ZNH [1055.hk]	2132 2117	0.004% (0.007%)	3.67% (3.85%)	-0.328 (-0.327)	0.241 (0.296)	0.301 (0.259)	9.672 (9.947)
HNP [0902.hk]	2202 2148	0.051% (0.054%)	3.29% (3.14%)	-0.166 (-0.167)	0.168 (0.207)	0.225 (0.383)	6.023 (6.775)
SHI [0338.hk]	3282 3330	0.021% (0.016%)	3.38% (3.80%)	-0.194 (-0.239)	0.271 (0.304)	0.512 (0.328)	9.324 (8.144)
YZC [1171.hk]	2105 2128	0.037% (0.049%)	3.76% (3.81%)	-0.454 (-0.487)	0.238 (0.268)	-0.454 (-0.848)	17.478 (18.087)

Table 4.3 provides descriptive statistics on returns on ADR and the underlying

[13] Since most Chinese ADRs have different listing date with H shares, for our particular research purpose, we choose sample period starting from the date when ADR or H shares listed later.

securities listed at SEHK. In portfolio I, the number of observations vary from 645 (CEO) to 2827 (CHL), while in Portfolio II, the minimum and maximum observations are 1504 (SNP) and 3282 (SHI) respectively. The annualized returns on the ADRs (Hong Kong shares) range from -67.75% (-37.56%) to 37.30% (30.42%) with a mean of 5.33% (5.91%), however, after splitting the ADRs and the underlying H shares into Portfolios I and II the means of ADR (H shares) break down as follows: 7.21% (7.28%) for Portfolio I and 2.53% (3.85%) for Portfolio II. Thus the average returns for portfolio I for the underlying H shares and ADRs are higher than those of Portfolio II. Further the H shares in Portfolio II seem to be outperforming their ADR counterparts.

The statistics show that three stocks, CHA, SNP, and YZC, either of the ADRs or of the H shares, are negatively skewed, although the skewness statistics are not large. The negative skewness implies that the return distributions of the shares have a heavier tail of large values and hence a higher probability of earning negative returns. The kurtosis values are very much larger than three, this result shows clearly that for most series, the distribution of return have fat tails compared with the normal distribution. It implies that much of the non-normality is due to leptokurtosis.

Next, we compute return spread as the difference between the returns of each ADR and that of its corresponding underlying H shares respectively. We select the return data by matching two data set at same date, since the US and Hong Kong market have different holidays, so we exclude the return data which cannot be matched. Our measure of *return spread* is same as Gagnon and Karolyi (2004) and Rabinovitch et al (2003). It denotes arbitrage profit and is equivalent to ADR premium, the percentage difference in prices between ADR and its underlying security.

Table 4.4: Statistical distribution of return spread ($r_t^{ADR} - r_t^{HK}$)

Symbol	Obs.	Mean	Std. Dev	Min	Max	Skewness	Kurtosis
Portfolio I							
ACH	1183	0.002%	0.9%	-0.040	0.036	-0.180	4.667
CBA	1251	-0.002%	0.826%	-0.050	0.038	-0.153	6.789
LFC	715	0.003%	1.56%	-0.104	0.066	-0.450	7.50
CHL	2161	0.000%	2.37%	-0.243	0.310	0.904	26.284
CHA	970	0.001%	1.45%	-0.061	0.064	0.168	4.605
CEO	645	0.000%	1.59%	-0.048	0.049	-0.058	8.194
GSH	2515	0.025%	3.09%	-0.218	0.300	0.099	12.856
PTR	1489	-0.007%	1.61%	-0.060	0.073	0.032	4.035
CHU	1587	-0.005%	2.28%	-0.145	0.136	0.105	7.51
Portfolio II							
CEA	2336	0.000%	1.56%	-0.120	0.129	-0.176	13.328
SNP	1501	-0.002%	0.81%	-0.090	0.061	-0.610	17.338
ZNH	2132	0.000%	3.09%	-0.352	0.244	-0.566	19.200
HNP	2090	-0.015%	0.024	-0.205	0.149	-0.600	11.877
SHI	3190	0.009%	1.54%	-0.105	0.122	-0.262	10.972
YZC	1929	0.032%	3.25%	-0.180	0.486	-0.718	30.417

Table 4.4 contains descriptive statistics on return spreads ($r_t^{ADR} - r_t^{HK}$) for 15 pairs of the Chinese ADRs separated into Portfolios I and II. The mean return spread is small, ranges from -1.5 basis point to 2.5 basis point[14], from the mean value of return spread, we can not predict that mispricing exists and the arbitrage profit will by some chance catch the attention of arbitrageurs. However, we notice the skewness is negative for four out of nine ADRs in portfolio I and negative for all ADRs in portfolio II. And once again, we find a large kurtosis in all ADRs, especially very much higher for the ADRs in portfolio II than those in portfolio I. A negative skew indicates the distribution is left-tailed, the left tail is longer than the right tail, and the larger is the kurtosis, the fatter is the distribution. The non-normality of the return and return spread series justify the examination on the return distribution. This finding suggests that compare to the Chinese ADRs in portfolio I, the Chinese ADRs in portfolio II are more likely to have lower return than their underlying H shares.

[14] 100 basis point accounts for 1%

4.5 Empirical tests and results

4.5.1 Tests on the law of one price

We next conduct several tests to determine whether the returns for ADR and their underlying HK securities are identical. We first apply t-test to compare mean and Wilcoxon signed-rank test to compare median for each pair of the ADRs. Kato et al. (1991) reported no arbitrage possibility exists by using these two location sensitive tests. Next, we follow Rabinovitch et al (2003) to use Kolmogorov-Smirnov test and the means and variances equality test to examine the return distribution for 15 pairs of the ADRs, and we report our results in table 4.5 and 4.6

Table 4.5: Equality tests on returns of the ADRs and H shares.
(*p* value in parentheses).

Symbol	**Two sample t-test**	**Wilcoxon signed-rank test**	**Kolmogorov-Smirnov test**
Portfolio I			
ACH	-0.0331(0.9736)	-0.207 (0.8362)	1.1959 (0.115)
CBA	0.1227(0.9736)	0.183 (0.8544)	1.6527 (0.010)***
LFC	-0.1289(0.8975)	-0.242 (0.8091)	1.0062 (0.001)***
CHL	-0.0577(0.9540)	0.042 (0.9663)	0.9193 (0.369)
CHA	-0.0058(0.9954)	-0.011 (0.9912)	2.4433 (0.000)***
CEO	-0.0161(0.9872)	0.148 (0.8820)	1.4069 (0.038)**
GSH	0.2861(0.7748)	-0.123 (0.9018)	1.8961 (0.001)***
PTR	-0.0779(0.9379)	0.143 (0.8866)	2.5826 (0.000)***
CHU	-0.1173(0.9066)	0.038 (0.9693)	1.3721 (0.046)**

Portfolio II			
CEA	0.0324(0.9741)	0.550 (0.5824)	2.0422 (0.000)***
SNP	-0.2595(0.7953)	-0.610 (0.5416)	2.6330 (0.000)***
ZNH	-0.0254(0.9797)	-0.304 (0.7614)	1.5380 (0.032)**
HNP	-0.7638(0.4451)	-0.470 (0.6383)	2.0749 (0.000)***
SHI	0.1454(0.8844)	0.592 (0.5540)	1.9546 (0.001)***
YZC	-0.0959(0.9236)	-0.630 (0.5285)	1.5287 (0.041)**

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

Table 4.5 reports the test results. First we conduct a paired *t*-test for differences in means. Column 2 contains the *t*-statistics for the difference in means test. Based on the *t*-statistics, we cannot reject the null hypothesis that there is no difference in means between the ADR and the corresponding underlying security returns at 10% or lower significance level for any of the 15 ADR-HK security pairs.

Second, in column 3, we report results from a non-parametric Wilcoxon signed-rank test. On the basis of the signed rank test results also we cannot reject the null hypothesis on the equality of medians between ADR and HK security returns for any of the 15 ADR-HK security pairs.

Third, in column 4, we report Kolmogorov-Smirnov test for testing the null hypothesis that the distributions ADRs and HK returns are identical. In statistics, the Kolmogorov–Smirnov test (the K-S test) is a goodness of fit test used to determine whether two underlying one-dimensional probability distributions differ, or whether an underlying probability distribution differs from a hypothesized distribution, in either case based on finite samples. The two-sample K-S test is one of the most useful and general nonparametric methods for comparing two samples, unlike t-test and the Wilcoxon signed-rank test which are only sensitive to differences in location, the K-S test is sensitive to differences in both location and shape of the empirical cumulative distribution functions of the two samples.

As the reported test statistics, KSa shows we reject the null hypothesis that ADR and underlying security returns distributions are identical at less than 10% significance level for 7 out of 9 pairs of securities (each ADR and its underlying HK security) from Portfolio I and reject the equality of the returns distributions for all ADRs and their underlying securities in Portfolio II. In addition to the differences in means and standard deviations in portfolio returns as stated earlier, here we find evidence of a structural difference between Portfolios I and II; however, the number of securities in each portfolio is too small to conduct a conclusive statistical test on the difference between the two portfolios.

Note that results of Kolmogorov-Smirnov test implying the inequality of two securities returns is due to dispersion of returns distribution, since two location tests t-test and Wilcoxon signed-rank test cannot reject the null hypothesis. And this is consistent with the small mean of return spread that we report in table 4.4. We then do a joint means and variance test as in Rabinovitch et al (2003) based on Bradley and Blackwood (1989) who assumed a joint parametric distribution of the means and variances equality.

Let r_t^{HK} and r_t^{US} denote the return on H share and ADR traded at day *t*, assume that the return distributions are elliptical and define $Y_t = r_t^{HK} - r_t^{US}$, $X_t = r_t^{HK} + r_t^{US}$, and $DEVX_t = X_t - \overline{X}$. Then, perform the following regression. The null hypothesis that β_0 =0 and β_1 =0 is against the alternative hypothesis that at least one of the coefficients is different from zero, namely the mean returns and the returns variances are simultaneously equal. We report F value of the null hypothesis in Table 4.6.

$$Y_t = \beta_0 + \beta_1 \ DEVX_t \ + \ e_t \qquad (4)$$

Table 4.6: F-test for joint means and variance tests
(t stat in parenthesis)

Symbol	Equality test		
	Constant (ß$_0$)	**DEVX(ß$_1$)**	**F-test**
Portfolio I			
ACH	$-4.13e^{-5}$(-0.03)	-0.034 (-1.21)	1.46
CBA	$1.41e^{-4}$(0.11)	-0.007 (-0.30)	0.09
LFC	$-1.03e^{-4}$(-0.09)	0.077**(2.25)	5.07**
CHL	$-4.91e^{-5}$ (-0.06)	0.063***(3.05)	9.30***
CHA	$-3.82e^{-5}$ (-0.04)	-0.008 (-0.25)	0.06
CEO	$-1.76e^{-5}$ (-0.02)	-0.042 (-1.10)	1.20
GSH	$2.22e^{-4}$(0.27)	-0.065***(-3.31)	10.99***
PTR	$-5.56e^{-5}$ (-0.08)	0.010 (0.43)	0.18
CHU	$-1.11e^{-4}$(-0.12)	0.063***(2.75)	7.56***
Portfolio I			
CEA	$3.42e^{-5}$ (0.03)	-0.166***(-8.35)	69.73***
SNP	$-2.32e^{-4}$(-0.26)	0.044*(1.68)	2.84*
ZNH	$-2.95e^{-5}$ (-0.03)	-0.044**(-2.05)	4.21**
HNP	$-5.75e^{-4}$(-0.76)	0.034***(2.50)	6.26***
SHI	$9.65e^{-5}$ (0.10)	-0.130***(-7.06)	49.84***
YZC	$-2.91e^{-4}$(-0.27)	-0.018 (-1.00)	1.00

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

On the basis of the reported F-tests we reject equality of both means and variances for four out of nine securities in Portfolio I but five out of six securities in Portfolio II at less than 10% significant level. The results again confirm a structural difference between Portfolio I and Portfolio II and that when returns variances are considered the returns distributions for ADRs and H shares are not identical.

Table4.7: Summary of test results of Tables 4.5 and 4.6.
('Yes' indicates rejection of the hypothesis while 'No' indicates null hypothesis cannot be rejected.)

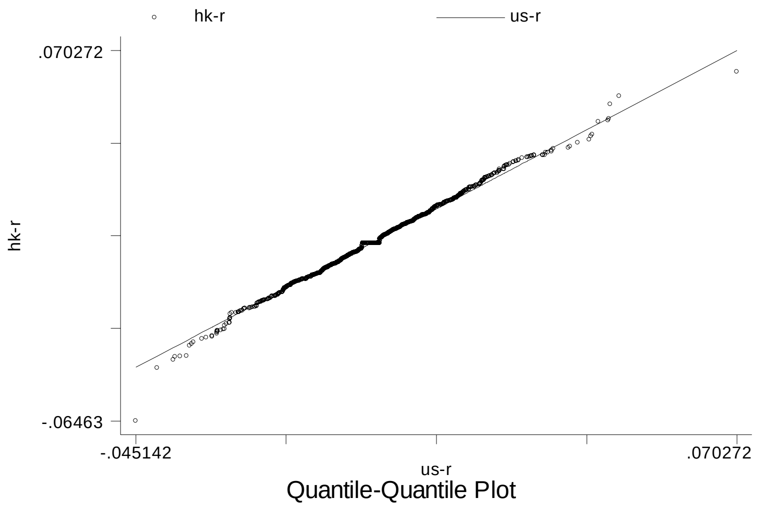
Symbol	Ksa	Wilcoxon signed-rank test	Two sample t-test	Joint means and variance tests
Portfolio I				
ACH	No	No	No	No
CBA	Yes	No	No	No
LFC	Yes	No	No	Yes
CHL	No	No	No	Yes
CHA	Yes	No	No	No
CEO	Yes	No	No	No
GSH	Yes	No	No	Yes
PTR	Yes	No	No	No
CHU	Yes	No	No	Yes
Portfolio II				
CEA	Yes	No	No	Yes
SNP	Yes	No	No	Yes
ZNH	Yes	No	No	Yes
HNP	Yes	No	No	Yes
SHI	Yes	No	No	Yes
YZC	Yes	No	No	No

We summarize the test results in Tables 4.5 and 4.6 in Table 4.7, which indicates the following. *a*) Standard locations tests are inadequate in capturing the differences between ADRs and the underlying securities returns. *b*) The distributions appear to be different primarily due to differences in variances and their tail masses (we provide Q-Q plots of normalized returns in Graph 4.2 to show how the tail areas are different from those of identical distributions). *c*) There are structural differences between Portfolio I and Portfolio II, which lead to differences in their returns distributions. This finding is appealing, because the most obvious difference between these two portfolios is whether these ADRs have A shares listed in China's domestic stock market, though there are also some differences in the industries that these ADRs belong to. The additional A shares listing gives rise to an increasing in the shareholder base, because the number of outstanding shares increase. At the same time, the A shares are only issued and traded in domestic market which is known as segmented with the Hong Kong and US market as we have introduced in chapter 2. The structural difference between two portfolios clearly tells us the investors would give the valuation of this additional A shares listing, in particular, the investors in the US tend to give negative assessment for it. Because the return spread in portfolio II are all negatively skewed, which indicates the ADRs return in portfolio II have higher possibility to be lower than their underlying H shares return.

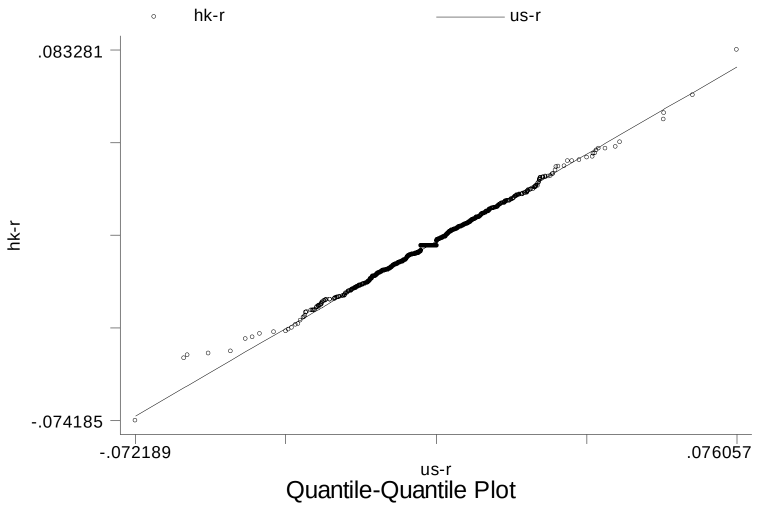
As mentioned earlier, in Graph 4.2 we provide Q-Q (quantile-quantile) plots of the normalized returns for ADR and the underlying H security. Q-Q plot visually checks for whether the data deviate from certain distribution, or whether two data sets come from populations with common distribution. A 45-degree reference line is also plotted. If the two sets come from a population with the same distribution, the points should fall approximately along this reference line.

Graph 4.2: Q-Q (Quartile-Quartile) plots of ADRs and H shares returns

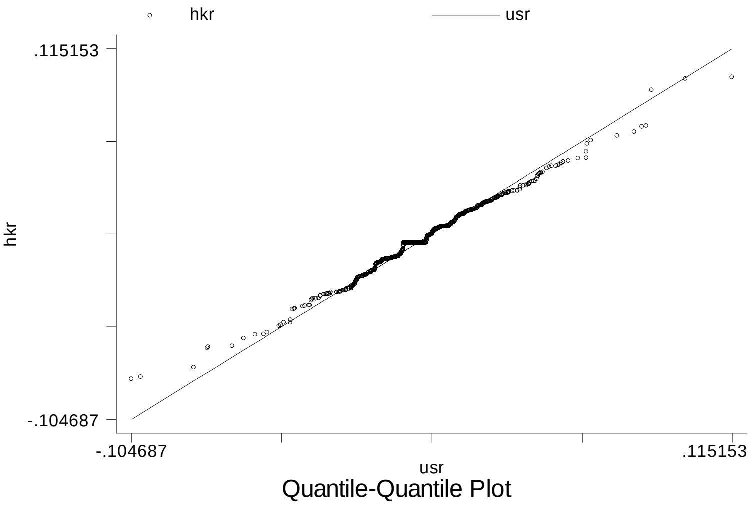
1. ACH



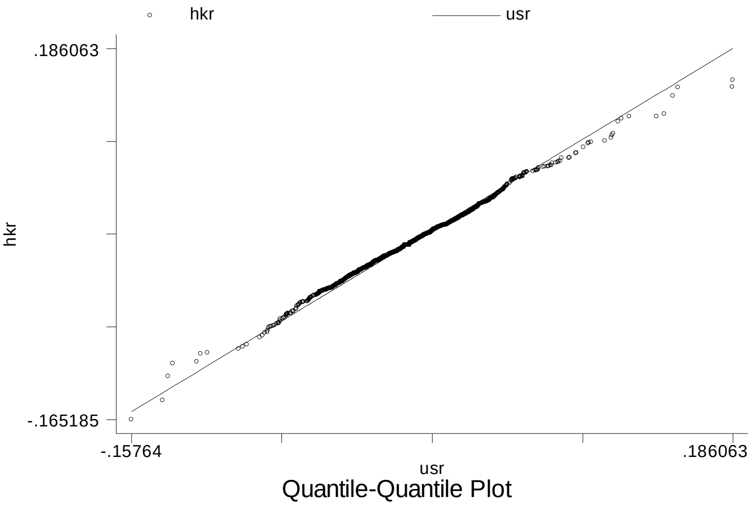
2. CBA



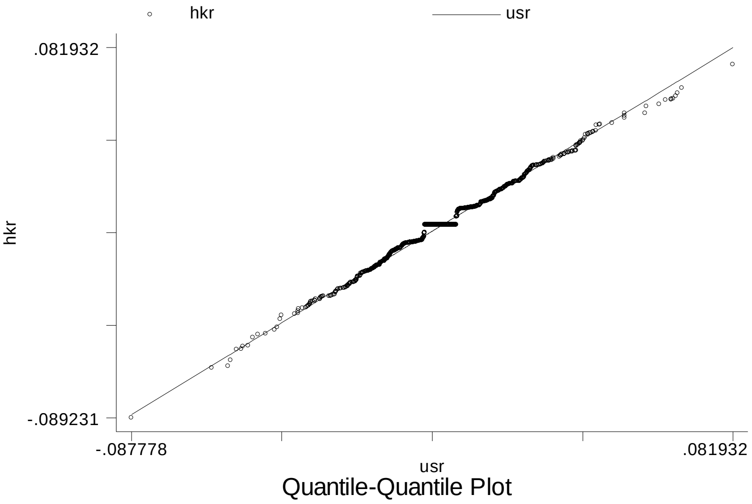
3. LFC



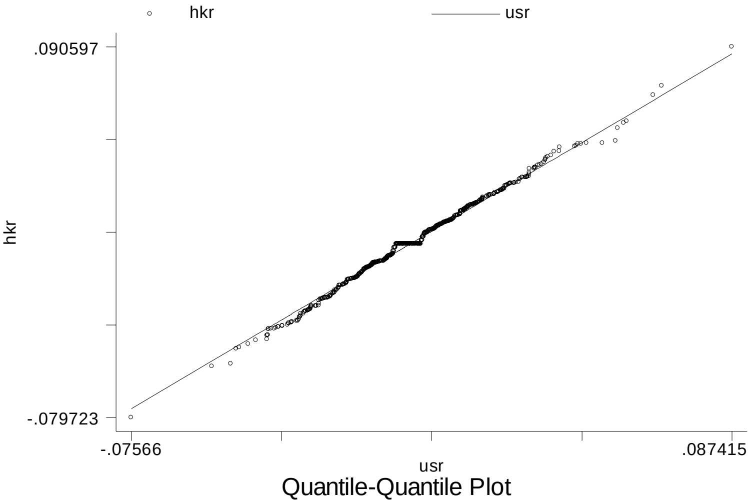
4. CHL



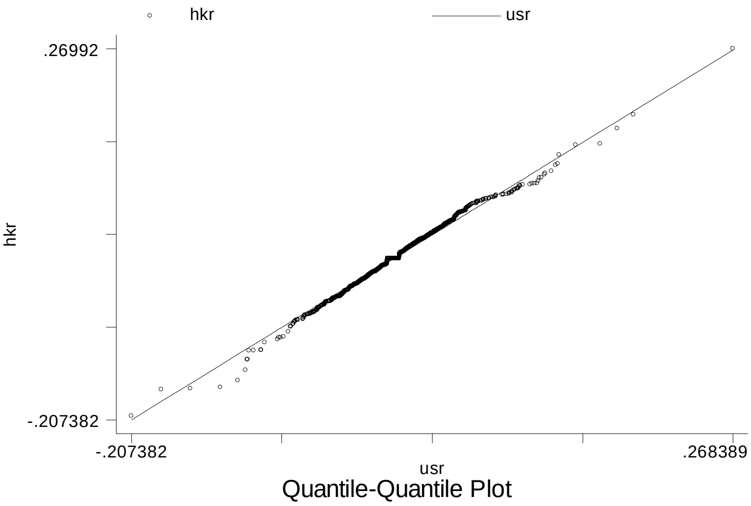
5. CHA



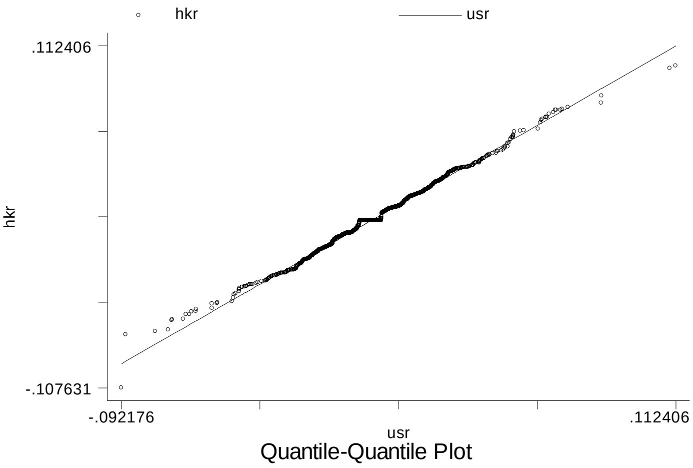
6. CEO



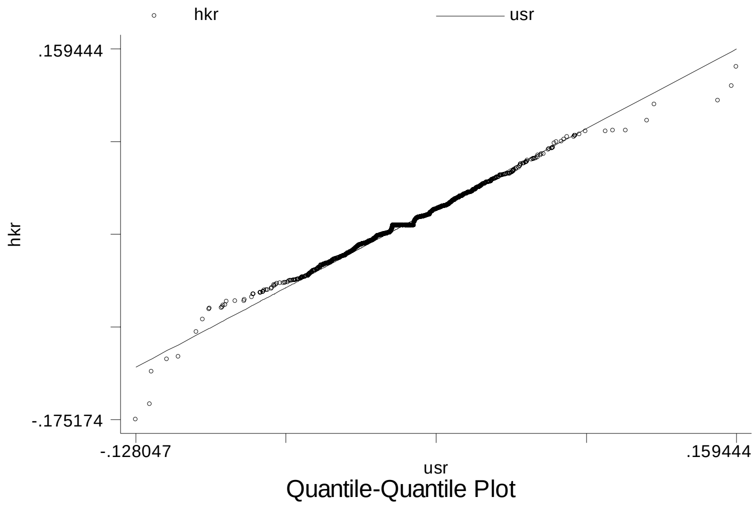
7. GSH



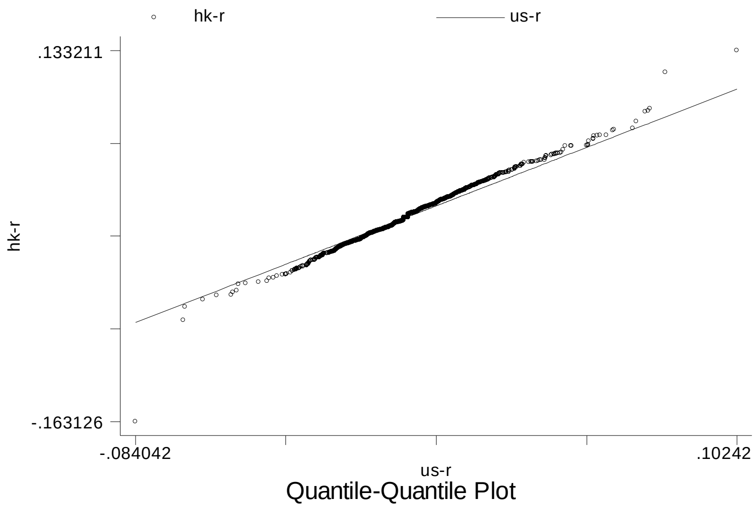
8. PTR



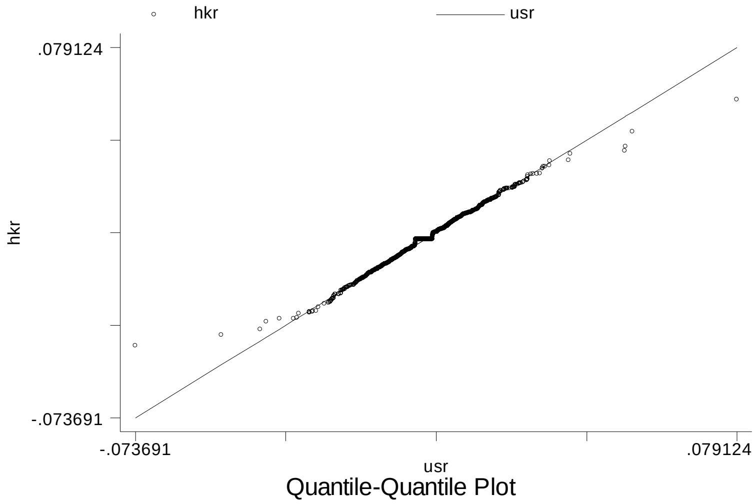
9. CHU



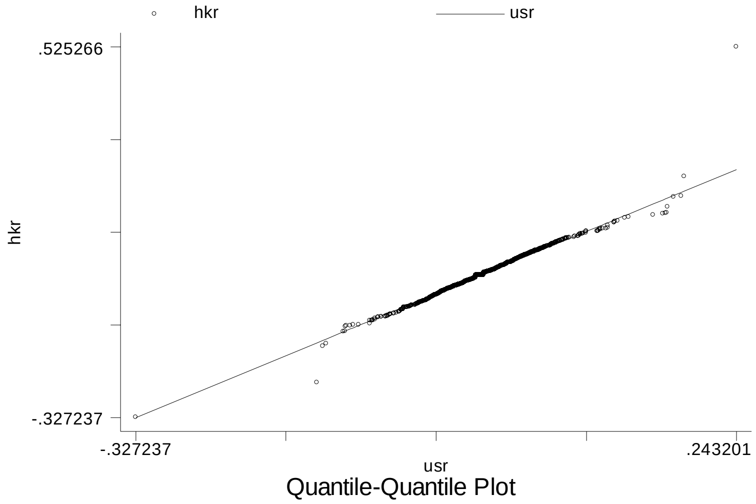
10. CEA



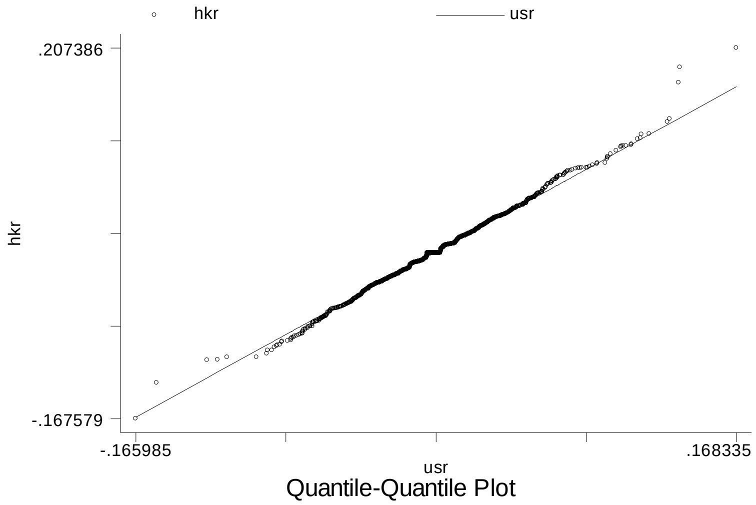
11. SNP



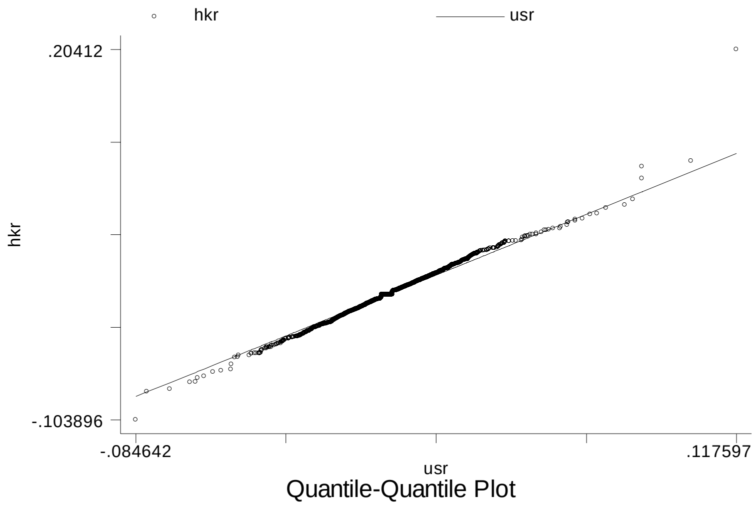
12. ZNH



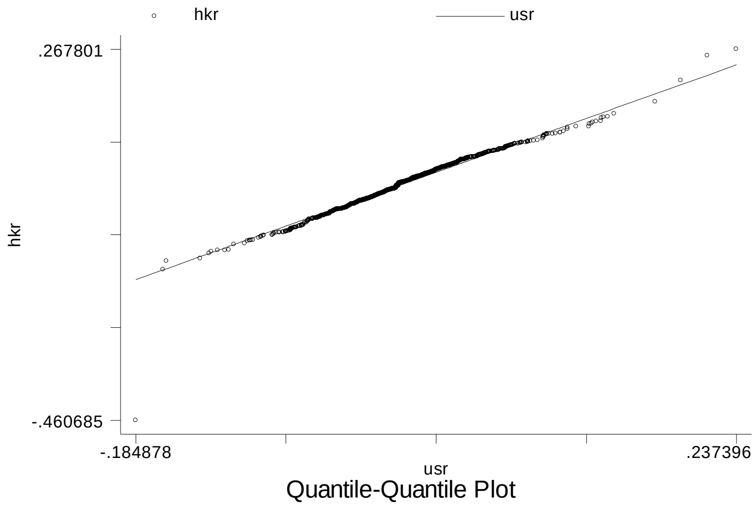
13. HNP



14. SHI



15. YZC



In the Q-Q plots, the horizontal axis measures the return of the ADRs, *usr* stands for r_t^{ADR}, and the vertical axis shows the return of the H shares, *hkr* stands for r_t^{HK}. There are four fractions in each axis, which means the first, the second, the third, and the forth quantiles of the distribution. The Q-Q plot describes the quantiles of the ADRs return against the quantiles of the H shares' return. By a quantile, we mean the fraction (or percent) of points below the given value. That is, the 25% quantile is the point at which 25% percent of the data fall below and 75% fall above that value.

A 45-degree reference line is plotted automatically by the software package (we use STATA). As we have already pointed out, if the two securities have the same distribution, the points should fall approximately along this reference line. The greater the departure from this 45-degree reference line, the greater of the evidence that the return of the ADRs and the H shares have different distributions. In our 15 plots, all ADRs have the points concentrated along the reference line between the first quantile and the third quantile, but all the ADRs have greater departure from the reference line at the quantiles which is greater than the third quantile or smaller than the first quantile, which means the return distribution of two securities are quite different at the tails. We also notice that the reference line in some plots are not 45 degree and the intercepts is not zero, for example, ACH, CHU, CEA, and YZC, a non-45 degree line usually stands for the difference in kurtosis of two returns.

In conclusion, we find two securities have quite different distributions in their returns, and the difference mainly comes from the tail and higher moments. The descriptive statistics of two securities return also indicates the return data are not normally distributed since all return series have the kurtosis which is higher than 3. The equality tests on return distribution and the descriptive statistics of return spread clearly show a structural difference between the two portfolios; we expect this difference may be due to the US investors' pessimistic attitude to the additional A shares listing.

4.5.2 Tests on the comovement effect on the mispricing

Next, we examine the pair-wise correlation between two securities' return and then the comovement effect with the local market indices. We use Spearman correlation test and Pearson Correlation test to measure the correlation between each pair of the ADRs by matching the returns during the same trading date, the number of observations can be accessed in table4.4. The null hypothesis is that $\rho(r^{ADR}, r^{HK}) = 0$ i.e., the Chinese ADRs and underlying H shares returns are uncorrelated. Since ADRs are claims on cash flows generated by their respective underlying shares, and the conversion mechanism between the ADRs and the underlying shares would force the prices of two securities to be close to each other. Therefore, intuitively, one would expect that the contemporaneous correlations between the two returns to be high (probably close to one). On the other hand, due to the difference in trading hours that Hong Kong market starts 12 hours earlier than the US market; we also expect the lead-lag correlation between the two securities to be high.

Table 4.8: Pearson and Spearman correlation test

(p value in parenthesis)

Symbol	**Spearman correlation** (r_t^{ADR}, r_t^{HK})	**Pearson correlation** (r_t^{ADR}, r_t^{HK})	**Spearman correlation** $(r_{t-1}^{ADR}, r_t^{HK})$	**Pearson correlation** $(r_{t-1}^{ADR}, r_t^{HK})$
ACH	0.722*** (0.000)	0.766*** (0.000)	0.242*** (0.000)	0.274*** (0.000)
CBA	0.772*** (0.000)	0.805*** (0.000)	0.151*** (0.000)	0.151*** (0.000)
LFC	0.687*** (0.000)	0.742*** (0.000)	0.194*** (0.000)	0.232*** (0.000)
CHL	0.679*** (0.000)	0.668*** (0.000)	0.263*** (0.000)	0.333*** (0.000)
CHA	0.659*** (0.000)	0.711*** (0.000)	0.202*** (0.000)	0.237*** (0.000)
CEO	0.621*** (0.000)	0.661*** (0.000)	0.283*** (0.000)	0.288*** (0.000)
GSH	0.495*** (0.000)	0.494*** (0.000)	0.202*** (0.000)	0.200*** (0.000)
PTR	0.625*** (0.000)	0.696*** (0.000)	0.239*** (0.000)	0.253*** (0.000)
CHU	0.629*** (0.000)	0.653*** (0.000)	0.260*** (0.000)	0.300*** (0.000)
CEA	0.539*** (0.000)	0.522*** (0.000)	0.239*** (0.000)	0.348*** (0.000)
SNP	0.676*** (0.000)	0.701*** (0.000)	0.183*** (0.000)	0.231*** (0.000)

ZNH	0.655*** (0.000)	0.664*** (0.000)	0.156*** (0.000)	0.229*** (0.000)
HNP	0.701*** (0.000)	0.702*** (0.000)	0.222*** (0.000)	0.289*** (0.000)
SHI	0.520*** (0.000)	0.528*** (0.000)	0.330*** (0.000)	0.402*** (0.000)
YZC	0.613*** (0.000)	0.606*** (0.000)	0.185*** (0.000)	0.206*** (0.000)

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

In Table 4.8 we report Pearson and Spearman correlation coefficients between (r_t^{ADR}, r_t^{HK}) and between (r_{t-1}^{ADR}, r_t^{HK}), and the corresponding significance levels between ADR and the underlying security returns. All the ADRs have significant positive correlation with their underlying H shares with regard to the contemporaneous and lead-lag relation. And the value of Spearman test is a bit lower than that from the Pearson test, but both tests are consistent in their level of significance and sign. One observation from this table is the contemporaneous correlations are not as high or close to one as intuition may have predicted. The contemporaneous correlations of Spearman test range from 0.495 for GSH to 0.772 for CBA, the lead-lag correlation of Spearman test range from 0.151 for CBA to 0.330 for SHI. These results are consistent with the findings of Kato et al. (1991). Although Kato et al. (1991) declaimed that their findings support the law of one price; they also demonstrated that the returns of the ADRs and the underlying stocks are neither perfectly, nor even near perfectly correlated, since the correlations are not close to one, and they suggested the non-overlapping trading hour is at least a partial explanations for this.

Therefore, we extend the research by Kato et al. (1991), and follow the approach of Gagnon and Karolyi (2004). We present our results of the time series model described in equation (1) in table 4.9.

Specifically, we use S&P 500, ^HIS, and ^SHA as three market indices respectively. S&P 500 is a market capitalization-weighted index that tracks the daily total return performance of 500 common stocks of large capitalization companies that are listed on the NYSE, AMEX, and NASDAQ. The S&P 500 accounts for about 64% of the market value of shares listed at the three exchanges. ^HSI is Hang Seng Index, which is a free float-adjusted market capitalization-weighted stock market index in Hong Kong. It is used to record and monitor daily changes of the largest companies of the Hong Kong stock market and is the main indicator of the overall market performance in Hong Kong. These 45 companies represent about 67% of market capitalization of the Hong Kong Stock Exchange. ^HSI is the most representative index of Stock Exchange of Hong Kong (SEHK), and is active from 1969. ^SHA is the index of all A-shares on the Shanghai Stock Exchange (SHSE), and is active from 1991. The reason not to use ^SSEC, the composite index of SHSE, is because ^SSEC also includes all B-shares on the SHSE; however A-shares and B-shares are two segmented markets.

The table 4.9 bellow reports summary statistics for time-series regressions of the Chinese ADRs and the underlying H shares return differences on the cotemporaneous and up to two lagged returns on the US market index, the underlying Hong Kong market index, and the home market index for the ADRs in portfolio II. The sample period ends on October 20, 2006, begins on various dates according to individual securities listing history, the number of the observations can be found in table 4.4. We perform the following model for the 15 pairs of the ADRs:

$$r_t^{ADR} - r_t^{HK} = \alpha^{US} + \sum_{i=-2}^{0} \beta_i^{US} R_{t+i}^{US} + \sum_{i=-2}^{0} \beta_i^{HK} R_{t+i}^{HK} + \varepsilon_t \qquad (1)$$

Table 4.9: Results of time series regression analysis

Portfolio I									
	ACH	**CBA**	**LFC**	**CHL**	**CHA**	**CEO**	**GSH**	**PTR**	**CHU**
α	0.000 (0.14)	0.000 (0.07)	0.000 (0.00)	0.000 (0.07)	0.000 (0.07)	0.000 (0.11)	0.000 (0.50)	0.000 (-0.02)	0.000 (-0.01)
β_t^{US}	0.278*** (11.55)	0.207*** (9.45)	0.868*** (11.51)	1.002*** (33.17)	0.812*** (16.87)	-0.314*** (-4.50)	0.388*** (7.61)	0.428*** (10.32)	1.001*** (20.61)
β_{t-1}^{US}	-0.153*** (-5.88)	-0.076*** (-3.23)	-0.761*** (-8.78)	-0.780*** (-23.55)	-0.554*** (-10.27)	-0.117* (-1.69)	-0.311*** (-5.70)	-0.345*** (-8.79)	-0.749*** (-17.83)
β_{t-2}^{US}	0.014 (0.56)	-0.008 (-0.35)	0.135* (1.65)	-0.010 (-0.31)	-0.115** (-2.23)	0.197*** (3.05)	0.254*** (4.42)	0.035 (0.32)	-0.014 (-0.33)
β_t^{HK}	-0.136*** (-5.09)	-0.069*** (-2.98)	-0.228*** (-3.78)	-0.320*** (-13.47)	-0.195*** (-4.73)	0.788*** (8.60)	0.003 (0.10)	-0.108*** (-3.03)	-0.357*** (-8.95)
β_{t-1}^{HK}	-0.007 (-0.28)	-0.022 (-1.14)	-0.106* (-1.74)	0.020 (0.83)	-0.071* (-1.68)	-0.445*** (-4.85)	-0.322*** (-6.76)	-0.054 (-1.15)	-0.037 (-0.98)
β_{t-2}^{HK}	0.100 (0.41)	0.020 (0.97)	0.078 (1.40)	0.063 (0.97)	0.086** (2.15)	-0.084 (-0.90)	0.071** (1.98)	0.063 (1.25)	0.064* (1.80)
Adj. R^2	16.87%	8.84%	29.6%	52.8%	34.84%	20.92%	6.58%	15.94%	45.57%
Portfolio II									
	CEA	**SNP**	**ZNH**	**HNP**	**SHI**	**YZC**			
α	0.000 (0.02)	0.000 (0.08)	0.000 (-0.14)	0.000 (0.10)	0.000 (0.41)	0.000 (0.48)			
β_t^{US}	0.148** (2.44)	0.208*** (10.57)	0.459*** (8.26)	0.521*** (12.43)	0.205*** (7.35)	0.258*** (3.41)			
β_{t-1}^{US}	-0.198*** (-7.01)	-0.149*** (-7.73)	-0.462*** (-8.05)	-0.330*** (-7.32)	-0.196*** (-7.16)	-0.221*** (-3.46)			
β_{t-2}^{US}	0.132 (1.08)	-0.001 (-0.63)	0.146** (2.19)	0.010 (0.74)	0.077*** (2.76)	0.062 (0.95)			
β_t^{HK}	0.026 (1.28)	-0.058*** (-3.22)	0.023 (0.42)	-0.128*** (-3.85)	0.008 (0.48)	-0.008 (-0.16)			
β_{t-1}^{HK}	-0.167*** (-8.69)	-0.023 (-1.34)	-0.235*** (-4.91)	-0.103*** (-3.19)	-0.177*** (-10.60)	-0.043 (-0.92)			
β_{t-2}^{HK}	0.023 (1.25)	0.016 (0.40)	0.017*** (0.42)	0.034 (1.02)	0.026 (1.58)	0.072 (1.40)			
β_t^{SH}	0.012 (0.59)	-0.014 (-1.01)	0.112*** (2.48)	-0.021 (-0.59)	0.004 (0.39)	0.066 (1.28)			
β_{t-1}^{SH}	0.002 (0.09)	0.007 (0.52)	-0.013 (-0.28)	-0.019 (-0.54)	0.026* (1.78)	-0.048 (-0.94)			
β_{t-2}^{SH}	-0.031 (-1.47)	-0.017 (-1.09)	-0.044 (-0.95)	0.088*** (2.48)	-0.015 (-1.26)	-0.042 (-0.81)			
Adj. R^2	7.06%	14.48%	8.68%	11.37%	7.46%	1.32%			

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

In table 4.9, we present summary statistics of time series estimates from the regression model described in Equation (1) for the 15 pairs of the ADRs grouped into two portfolios in our sample. We find that for all 15 pairs of ADRs, return differentials exhibit intercept coefficients nearly to be zero. With regard to the *contemporaneous* comovement effect, we find the positive and significant exposure to the US market index (β_t^{US}) for all ADRs but CEO, while for the estimation of the coincident underlying market index (β_t^{HK}), we find significant negative relation in ten ADRs. With respect to the *lagged* comovement effect; we find negative and significant exposure to the US market index with one lag (β_{t-1}^{US}) for all ADRs, and negative and significant exposure to the underlying Hong Kong market index with one lag (β_{t-1}^{HK}) for eight ADRs. The exposure to each market index with two period lags (β_{t-2}^{US}, β_{t-2}^{HK}) is less than the exposure to the contemporaneous and one period lagged market index, we find positive significant estimation for five ADRs in terms of β_{t-2}^{US}, and positive significant estimation for four ADRs in terms of β_{t-2}^{HK}. We believe the relatively smaller in magnitude and the less in significant estimations of β_{t-2}^{US}, β_{t-2}^{HK} suggest that the comovement effect is a short-run effect, and this is also consistent with the conclusion in De Jong et al. (2003).

Second, while the effects of the US and Hong Kong market index returns on security returns are consistently significant for most of the ADRs return differentials, the exception is for CEO which shows an opposite market beta estimation with negative correlation with the US market index but positive correlation with the Hong Kong market index. We also note that the evidence of isolated home country effect is insignificant. We only find significant Shanghai market beta in three ADRs, namely ZNH, HNP and SHI. Our sample is too small and the number of firms displaying such anomalies is even smaller and thus we refrain from generalizing the exceptions; however, we note that similar evidence of scattered security specific effects are documented in Alberton et al (2001) and Chakrovarty (2005).

Third, our results of the *contemporaneous* coefficient of the US and Hong Kong market indices are consistent with De Jong et al. (2003) and Gagnon and Karolyi (2004), they reported significant positive relations between return differentials and the US market index and significant negative relations between return differentials and the home market index at a *contemporaneous* level. This finding is also in line with our prediction in section 4.3.2. However, unlike De Jong et al. (2003) and Gagnon and Karolyi (2004) that they did not find any significant estimation with regard to the lagged market indices, while we find for most of the Chinese ADRs, the return differentials are significantly negative with the one period lagged US and Hong Kong market indices. It is not difficult to understand a negative relation with the lagged Hong Kong market index, for instance, a positive shock in the Hong Kong market at day 0 will lead to a rise in the H shares return at day 1 and therefore a drop in the return differentials at day 1. The consistently significant negative relations with the lagged US market (β_{t-1}^{US}) for all the ADRs seems odd. However, we find similar evidence from Kim et al. (2000), who studied the dynamic relation between ADRs' return and the S&P 500 in a long horizon. They found the ADRs response to the innovation of the S&P 500 is large, positive and highly significant at day 0, and followed by a large, significant negative price response on day 1. They argued that it is because ADRs are clearly overreacting to innovations in the S&P 500 Index. Therefore, our findings offer new evidence for the existence of mispricing of the ADRs and new attributions to the limits of the arbitrage, that mispricing of the ADRs is not only caused by the *contemporaneous* comovement effect but also the *lagged* comovement effect with the local market index. We believe this finding will be very useful for hedge funds managers to design arbitrage strategy, since short-selling is not restricted in both the US and Hong Kong market.

Finally, we also notice an interesting pattern of the estimated *betas* that are quite different between two portfolios. We then turn our attention to the value of the *betas* on the portfolio level. We summarize the mean of each coefficients of the estimation in equation (1), and perform F test; our null hypothesis is that the estimated betas for the US and Hong Kong market risk are jointly equal in both mean and variance between two portfolios, we report our results in table 4.10.

Table 4.10. F test on joint equality of mean and variance between two portfolios

	Mean		Variance		F statistics (*p* value)	No. of significant estimations	
	Portfolio I	Portfolio II	Portfolio I	Portfolio II		Portfolio I	Portfolio II
β_t^{US}	0.519	0.299	0.193	0.002	8.306** (0.016)	(+) 8 (-) 1	(+) 6
β_{t-1}^{US}	-0.427	-0.262	0.083	0.015	5.478** (0.038)	(-) 9	(-) 6
β_{t-2}^{US}	0.054	0.071	0.013	0.003	3.746* (0.08)	(-) 1 (+) 3	(+) 2
β_t^{HK}	-0.069	-0.022	0.116	0.003	32.472*** (0.00)	(-) 7 (+) 1	(-) 2
β_{t-1}^{HK}	-0.116	-0.124	0.025	0.006	3.695* (0.08)	(-) 4	(-) 4
β_{t-2}^{HK}	0.051	0.031	0.003	0.0004	6.95** (0.02)	(+) 3	(+) 1

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

We report mean and variance for each correlation coefficients for two portfolios respectively, the F statistics with the p value are reported, we also report the number of significant coefficients with specifying positive or negative correlation coefficients, for example, '(+) 6' means we get 6 significantly positive coefficients.

Interestingly, table 4.10 is clearly showing structural difference between two portfolios. The F statistics reject the equality of mean and variance between two portfolios for all estimated *betas*. Bearing in mind that in table 4.4 which summarizes the description of the return spread, we find that all ADRs in portfolio II, but only four out of nine ADRs in portfolio I have negatively skewed tail. Once again, in section 4.5.1, the test on the law of one price, we also find two portfolios have different patterns in the return distribution. Therefore, we may attribute one of the reasons for the difference in two portfolios to the various magnitude comovement effects of the two markets.

Furthermore, as we can see from table 4.10, with regard to the *betas* on the US market index; the means are 0.519/0.299, -0.427/-0.262, and 0.054/0.071 for two portfolios respectively, while with regard to the *betas* on the Hong Kong market index, the means are -0.069/-0.002, -0.116/-0.124, and 0.051/0.031 for two portfolios respectively. This indicates the ADRs expose to higher systematic risk of the US market than that of the Hong Kong market, and this is same as the findings in Gagnon and Karolyi (2004).

In conclusion, the two steps investigations on the existence of the ADRs mispricing show that the significant positive correlations between pair-wised two securities returns have limitation in the argument that the law of one price is applicable to the ADRs and their underlying shares. Although we find significant positive correlated ADRs return and H shares return, and similar magnitude in the correlation coefficients like Kato et al. (1991), we still find evidence of the existence of the mispricing between two securities. We attribute to the contemporaneous comovement effect with the local market index (Gagnon and Karolyi, 2004), as well as the US based investors' prolonged over reaction to the innovations in the US market (Kim et al. 2000).

4.5.3 Test on the liquidity effect

We will now calculate two liquidity proxies, $liq_t = \log(vol_t)$, $ILLIQ_t = |r_t|/vol_t$ for ADRs and H shares respectively. Both ADRs and H shares are frequently traded in two markets; the none-trading days account for less than 1% of the total sample period for most of the ADRs and H shares. We exclude the data with zero trading value to avoid the unnecessary exaggerated variance, and since only a handful of data has been deleted, we believe it will not change the results of our time series regression estimation. We report the descriptive statistics of two liquidity proxies and the correlation coefficient between two liquidity measures for both the ADRs and H shares in table 4.11.

Table 4.11: Descriptive statistics of liquidity proxies

Symbol	**Obs.**	liq_t Log(volume)		$ILLIQ_t$		**Corr. of** liq_t **and** $ILLIQ_t$ **(ADR)**	**Corr. of** liq_t **and** $ILLIQ_t$ **(HK)**
		mean	Std. Dev	mean	Std. Dev		
ACH [2600.hk]	1166	5.099 5.431	0.751 0.299	7.12e-07 8.28e-07	3.92e-06 8.18e-06	-0.596***	-0.130***
CBA [1114.hk]	1190	4.213 5.144	0.512 0.446	2.029e-06 3.83e-07	3.84e-06 2.826e-06	-0.593***	-0.449***
LFC [2628.hk]	701	5.10 6.20	0.525 0.287	1.29e-07 8.66e-09	1.465e-07 7.83e-09	-0.498***	-0.138***
CHL [0941.hk]	2154	5.460 6.567	0.426 0.233	1.02e-07 5.22e-09	1.68e-07 5.46e-09	-0.532***	-0.157***
CHA [0728.hk]	951	4.948 5.897	0.337 0.255	1.52e-07 1.79e-08	1.27e-07 1.67e-08	-0.292***	-0.213***
CEO [0883.hk]	627	5.157 5.808	0.256 0.226	1.04e-07 2.39e-09	8.90e-08 2.26e-09	-0.356***	-0.189***
GSH [0525.hk]	2566	4.146 5.011	0.577 0.392	2.01e-06 2.63e-07	4.05e-06 6.73e-07	-0.518***	-0.333***

PTR [0857.hk]	1468	5.198 5.939	0.592 0.272	1.94e-07 1.59e-08	3.50e-07 1.50e-08	-0.700***	-0.143***
CHU [0762.hk]	1550	5.459 6.227	0.399 0.257	8.68e-08 1.06e-09	1.31e-07 9.15e-10	-0.484***	-0.123***
CEA [0670.hk]	2317	3.735 5.081	0.705 0.468	6.73e-06 8.33e-09	1.59e-05 1.51e-09	-0.603***	-0.429***
SNP [0386.hk]	1485	4.953 5.813	0.575 0.332	4.09e-07 3.08e-08	7.88e-07 3.93e-07	-0.676***	-0.389***
ZNH [1055.hk]	2089	3.948 5.135	0.605 0.419	5.69e-06 6.53e-08	1.58e-05 2.71e-07	-0.608***	-0.397***
HNP [0902.hk]	2067	5.069 6.668	0.397 0.608	1.93e-07 8.55e-08	3.36e-07 1.61e-08	-0.348***	-0.618***
SHI	3178	4.249 5.145	0.528 0.449	1.87e-06 1.32e-07	7.30e-06 3.89e-07	-0.567***	-0.419***
YZC	1919	3.838 5.223	0.731 0.375	9.87e-06 2.14e-07	2.64e-05 3.93e-07	-0.628***	-0.458***

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

We then report summary statistics for time-series regressions of the liquidity effect on return spreads in table 4.12. The sample period ends on October 20, 2006, begins on various dates according to individual securities listing history, the number of the observations can be accessed in table 4.11. This model is tested based on daily data. We perform the following model for the 15 pairs of the ADRs, ILLIQ is scaled up by multiplying 10^5, *t*-statistics are reported in parenthesis.

$$r_t^{ADR} - r_t^{HK} = \alpha + \beta_1^{ADR} ILLIQ_t^{ADR} + \beta_2^{HK} ILLIQ_t^{HK} + \varepsilon \qquad (2)$$

$$r_t^{ADR} - r_t^{HK} = \alpha + \beta_3^{ADR} liq_t^{ADR} + \beta_4^{HK} liq_t^{HK} + \varepsilon \qquad (3)$$

Table 4.12: Liquidity effects.

Symbol	liq_t^{ADR}	liq_t^{HK}	$ILLIQ_t^{ADR}$	$ILLIQ_t^{HK}$	Adj R^2
ACH	0.008*** (2.64)	-0.016*** (-3.07)			7.93%
			0.002** (2.14)	-0.14 (-0.97)	1.22%
CBA	0.006* (1.82)	-0.016*** (-3.50)			2.90%
			0.004 (1.44)	-0.084 (-1.54)	1.02%
LFC	0.003*** (2.31)	-0.007 (-1.41)			6.70%
			0.005 (0.58)	-0.026*** (-2.32)	2.69%
CHL	0.003** (1.93)	-0.002 (-0.61)			4.55%
			0.195*** (3.29)	-0.007 (-1.15)	2.29%
CHA	0.007*** (2.25)	-0.010*** (-2.14)			3.83%
			0.021* (1.79)	-0.723** (-2.16)	3.31%
CEO	0.004** (2.10)	-0.008*** (-4.17)			5.02%
			0.065* (4.07)	-0.322* (-3.17)	3.45%
GSH	0.007*** (2.78)	-0.011*** (-2.85)			5.13%
			0.06 (0.04)	-0.014* (-1.84)	1.25%
PTR	0.004** (1.90)	-0.006** (-1.91)			5.05%
			0.005 (0.26)	-0.069 (-1.49)	1.02%
CHU	0.005*** (1.97)	-0.009* (-2.55)			3.45%
			0.074 (1.26)	-0.003 (-0.66)	0.98%
CEA	0.007*** (2.80)	-0.004 (-1.03)			4.03%
			-0.004 (-0.45)	-0.009 (1.72)	0.89%

SNP	0.002 (0.93)	-0.004 (-1.10)			2.87%
			0.016 (1.46)	0.017 (0.21)	0.96%
ZNH	0.005 (1.34)	-0.001 (-0.27)			5.03%
			0.002 (1.07)	-0.036 (-1.32)	0.90%
HNP	0.007* (1.88)	-0.006* (-1.92)			2.21%
			-0.001 (-0.28)	-0.002* (-1.87)	0.87%
SHI	0.009*** (3.39)	-0.017*** (-2.83)			6.33%
			0.001 (1.28)	-0.002* (-1.83)	1.20%
YZC	0.004*** (2.66)	-0.008*** (-2.49)			5.12%
			-0.0003 (-0.59)	0.0002 (1.07)	0.78%

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

The results in table 4.12 are consistent with our expectations regarding the relation between the return differentials and the trading volume as well as illiquidity. By employing trading volume as a measure of liquidity risk, we predict a positive relation between liquidity risk and return. An increase in the liquidity risk of the ADRs will lead to a rise in the ADRs' return, and therefore a rise in return spread. Likewise, an increase in the liquidity risk of the H shares will lead to a rise in the H shares' return, and therefore a drop in return spread. We find the signs of the estimated *betas* on the ADRs trading volume are consistently positive with return spread, and H shares trading volume are consistently negative. The coefficients of trading volume are significant for 10 pairs of ADRs and H shares. With the rest of 5 pairs of the

ADRs and H shares, we only find significant coefficients in ADRs trading volume for three ADRs, namely LFC, CHL, and CEA. Further, we notice the magnitude of the estimated correlation coefficients ranges from 0.009 for SHI as the ADRs to -0.017 for SHI as the underlying H shares. The adjusted R^2 ranges from 2.21% for HNP to 7.93% for ACH.

With regard to the illiquidity measure, as we predict in the previous section that there should be a positive relation between illiquidity and return. An increase in the illiquidity of the ADRs will lead to a rise in the ADRs' return, and therefore a rise in return spread. Likewise, an increase in the illiquidity of the H shares will lead to a rise in the H shares' return, and therefore a drop in return spread. We find for 12 pairs of the ADRs and H shares, the signs of the estimated correlation coefficients of the ADRs illiquidity are consistently positive, and that of the H shares' illiquidity are consistently negative. But in these 12 pairs of the ADRs, the coefficients are significant only in 2 pairs, namely CHA and CEO, 8 pairs of ADRs have significant coefficient in either ADRs illiquidity or H shares illiquidity. And the adjusted R^2 ranges from 0.78% for YZC to 3.45% for CEO. The illiquidity measure seems to have less explanatory power than trading volume. We expect illiquidity to be a more noisy measure of liquidity than the trading volume since it is measured as daily absolute returns per unit of volume, as we know daily time series data usually has higher variance than weekly or monthly time series data, and high variance may lower the significant level of the estimation.

Therefore, we have demonstrated that apart from the comovement effect from local market index, liquidity effect can also explain the mispricing of the ADRs. However, from the relatively small R^2 of the liquidity effect regression, we believe the comovement effect would dominate over the liquidity effect.

4.5.4 Structural change

As far as the empirical investigations have gone through, we now have a clear image about the arbitrage possibility of the Chinese ADRs. We have shown that the difference in the return distribution between the ADRs and the H shares lead to the possible return differentials and this mispricing is persistent for an extended period because the market-based, information-based, and trading-based barriers hamper arbitrage activity. We have found strong evidence of contemporaneous and lagged comovement effect from the local market index; we also found obvious evidence for liquidity risk effect.

Specifically, we have found that two portfolios have apparently different patterns in the comovement effect. The most distinguishing characteristics of these two portfolios is while one portfolio is with additional A shares listed in Shanghai Stock Exchange, the other is without. We have also found some isolated comovement effect from Shanghai stock market in the comovement effect examination. This finding addresses the question that how does the innovation in Shanghai stock market influence the Chinese ADRs listed in the NYSE? As we have discussed in chapter 2, a set of important reformation took place around 2003 in China. On November 5, 2002 the CSRC and the People's Bank of China (PBOC) introduced the QFII (Qualified Foreign Institutional Investor) program as a provision for foreign capital to access China's financial markets, and the important non-tradable shares reform starting from the end of 2002. For this, we believe that the year 2003 to be a breaking point to test if there is any structural change in the comovement effect from the domestic market.

On the other hand, observing the listing dates of the Chinese ADRs as indicated in Graph 4.1, more than 50% (8/15) ADRs were listed between 2000 and 2003. We believe a reasonable hypothesis for this structural shift in 2000 may be the market collapse in the US, particularly the IPO market, which led some Hong Kong firms to offer their securities to the US investors as alternative investment options. Therefore, we decide to study further about the impact from the market innovations in terms of the comovement effect. We select two breaking points, the year of 2000 and 2003, the former date stands for the innovations in the US market, and the later date represents the reformations in the China's stock market. Econometrically, we test this structural break/shift via a Chow test that requires the break periods to be known a priori.

Chow test is to test the equality of regression coefficients over two sample periods conditional on the equality of error variances. It is commonly used to test for a structural break. The model in effect uses an F-test to determine whether a single regression is more efficient than two separate regressions involving splitting the data into two sub-samples.

We will report summary statistics for structural change test in table 4.13. The sample period ends on October 20, 2006, begins on various dates according to individual securities listing history, the number of the observations can be found in table 4.4. We divide the sample period into three sub-periods, before 2000, 2000-2003, and after 2003, for the ADRs listed before 2000, the sub-periods will be three, while for the ADRs listed after 2000, the sub-periods will be two. Three ADRs, namely LFC, CHA, and CEO are excluded from the structural change test, because their listing date is in 2003, which makes our observation number for the period of post-2003 too limited. We perform the following model for the 15 pairs of the ADRs, for the ADRs in portfolio II, we in addition include the market index of Shanghai:

$$r_t^{ADR} - r_t^{HK} = \alpha^{US} + \sum_{i=-2}^{0} \beta_i^{US} R_{t+i}^{US} + \sum_{i=-2}^{0} \beta_i^{HK} R_{t+i}^{HK} + \varepsilon_t$$

Table 4.13: Structural change

Portfolio I							
symbol	ACH		CBA		CHL		
Sub-period	01-03	03-	01-03	03-	-00	00-03	03-
β_t^{US}	0.163*** (4.78)	0.387*** (11.53)	0.092*** (2.83)	0.343*** (11.02)	1.04*** (14.98)	1.03*** (19.34)	1.03*** (25.07)
β_{t-1}^{US}	-0.082** (-2.17)	-0.253*** (-6.97)	-0.003 (-0.10)	-0.162*** (-4.82)	-0.752*** (-9.91)	-0.809*** (-13.53)	-0.697*** (-15.65)
β_{t-2}^{US}	0.771 (1.04)	-0.054 (-1.52)	0.039 (1.09)	-0.075*** (-2.24)	-0.068 (-0.91)	0.071 (1.19)	-0.087** (-1.97)
β_t^{HK}	-0.016 (-1.31)	-0.168*** (-5.56)	-0.062 (-1.51)	-0.063** (-2.25)	-0.326*** (-8,58)	-0.362*** (-6.85)	-0.226*** (-6.13)
β_{t-1}^{HK}	-0.048 (-1.44)	0.014 (0.47)	-0.020 (-0.51)	-0.023 (-2.82)	0.059 (1.26)	-0.029 (-0.55)	-0.023 (-0.64)
β_{t-2}^{HK}	-0.061 (-1.32)	0.036 (1.30)	-0.024 (-0.66)	-0.005 (0.44)	0.081 (1.40)	-0.023 (-0.49)	0.089 (1.26)
Adj. R^2	12.16%	21.85%	3.5%	16.66%	50.52%	50.82%	56.22%
Chow	8.57***		9.76***		5.34***		
symbol	GSH			PTR		CHU	
Sub-period	96-00	00-03	03-	00-03	03-	00-03	03-

β_t^{US}	0.528*** (4.07)	0.237*** (4.34)	0.501*** (7.27)	0.271*** (6.03)	0.735*** (12.41)	1.03*** (18.21)	0.95*** (15.82)
β_{t-1}^{US}	-0.600*** (-4.21)	-0.077 (-1.26)	-0.294*** (-3.96)	-0.311 (-6.16)	-0.435*** (-6.77)	-0.768*** (-12.06)	-0.701*** (-10.70)
β_{t-2}^{US}	-0.595*** (-4.16)	0.039 (0.64)	0.076 (1.02)	0.060 (1.14)	-0.061 (-0.97)	0.167 (0.26)	-0.067 (-1.04)
β_t^{HK}	-0.162** (-2.20)	-0.193*** (-3.51)	-0.163*** (-2.68)	-0.026 (-0.55)	-0.220*** (-4.18)	-0.394*** (-6.55)	-0.298*** (-5.44)
β_{t-1}^{HK}	-0.511*** (-6.98)	-0.021 (-0.39)	-0.107** (-1.97)	0.009 (0.20)	-0.145*** (-2.75)	-0.036 (-0.61)	-0.043 (-0.79)
β_{t-2}^{HK}	0.038 (0.57)	0.080 (1.54)	0.060 (1.09)	0.026 (0.61)	-0.124 (-1.34)	0.072 (0.89)	0.036 (0.73)
Adj. R^2	9.98%	5.55%	9.72%	13.59%	24.01%	50.63%	34.65%
Chow	24.54***			8.97***		7.89***	
Portfolio II							
symbol	CEA			SNP			
Sub-period	97-00	00-03	03-	00-03	03-		
β_t^{US}	0.244*** (3.28)	0.087*** (3.31)	0.145*** (4.75)	0.163*** (6.15)	0.289*** (11.41)		
β_{t-1}^{US}	-0.480*** (-5.91)	-0.007 (-0.26)	-0.119*** (-3.64)	-0.140*** (-4.72)	-0.189*** (-6.91)		
β_{t-2}^{US}	0.325 (1.08)	0.019 (0.64)	0.031 (0.96)	-0.002 (-0.10)	-0.010 (-0.39)		
β_t^{HK}	-0.157*** (-3.82)	-0.159*** (-5.96)	-0.097*** (-3.56)	-0.001* (-1.69)	-0.124*** (-5.42)		
β_{t-1}^{HK}	-0.302*** (-7.29)	0.019 (0.73)	0.038 (1.23)	-0.008 (-0.29)	-0.050** (-2.20)		
β_{t-2}^{HK}	0.004 (0.11)	0.025 (1.03)	-0.029 (-1.17)	-0.018 (-0.72)	0.067 (1.16)		
β_t^{SH}	-0.070* (-1.71)	-0.031 (-1.53)	-0.009 (-0.54)	-0.003 (-0.08)	-0.022* (-1.86)		
β_{t-1}^{SH}	-0.015 (-0.31)	0.025 (0.90)	-0.003 (-0.17)	0.021 (0.72)	0.003 (0.25)		
β_{t-2}^{SH}	-0.072 (-1.46)	-0.030 (-1.10)	0.014 (0.77)	-0.040 (-1.40)	-0.002 (-0.02)		
Adj. R^2	15.75%	8.44%	7.24%	12.07%	23.33%		
Chow	15.87***			16.02***			
Symbol	ZNH			HNP			
Sub-period	98-00	00-03	03-	98-00	00-03	03-	
β_t^{US}	0.399*** (2.05)	0.479*** (8.15)	0.526*** (7.55)	1.101*** (8.32)	0.269*** (5.15)	0.487*** (8.45)	

β_{t-1}^{US}	-0.896*** (-4.30)	-0.294*** (-4.49)	-0.262*** (-3.53)	-0.758*** (-5.32)	-0.157*** (-2.80)	-0.342*** (-5.72)	
β_{t-2}^{US}	0.605*** (2.90)	0.021 (0.33)	-0.120* (-1.82)	-0.079 (-0.57)	-0.001 (-0.03)	0.054 (0.91)	
β_{t}^{HK}	-0.425*** (-3.35)	-0.201*** (-3.43)	-0.288*** (-4.57)	-0.109 (-1.29)	-0.099** (-1.96)	-0.192*** (-3.88)	
β_{t-1}^{HK}	-0.655*** (-5.13)	-0.051 (-0.87)	0.210 (1.33)	-0.122 (-1.51)	-0.099** (-1.94)	-0.003 (-0.07)	
β_{t-2}^{HK}	-0.121 (-1.02)	-0.012 (-1.56)	0.055 (0.95)	-0.026 (-0.36)	0.090 (1.48)	-0.123*** (-2.58)	
β_{t}^{SH}	-0.370 (-0.26)	0.010 (0.15)	0.029 (0.70)	-0.019 (-0.18)	-0.027 (-0.49)	-0.051* (-1.84)	
β_{t-1}^{SH}	-0.099 (-0.61)	0.034 (0.55)	-0.007 (-0.19)	-0.165* (-1.84)	0.051 (0.92)	0.011 (0.34)	
β_{t-2}^{SH}	-0.052 (-0.32)	-0.089 (-1.42)	0.004 (0.01)	-0.258 (-2.48)	0.009 (0.17)	0.012 (0.38)	
Adj. R^2	13.23%	14.22%	10.85%	22.33%	7.54%	14.22%	
Chow	6.98***			7.05***			
Symbol	SHI			YZC			
Sub-period	93-00	00-03	03-	98-00	00-03	03-	
β_{t}^{US}	0.177*** (3.36)	0.173*** (6.45)	0.301** (10.19)	0.205 (1.02)	0.146** (2.02)	0.651*** (7.25)	
β_{t-1}^{US}	-0.397*** (-6.88)	-0.029 (-0.97)	-0.149*** (-4.69)	-0.380* (-1.78)	-0.019 (-0.24)	-0.411*** (-4.30)	
β_{t-2}^{US}	0.232*** (4.02)	-0.014 (-1.34)	-0.065** (-2.09)	0.123 (0.58)	0.099 (1.24)	-0.096 (-1.01)	
β_{t}^{HK}	-0.089*** (-3.26)	-0.108*** (-3.89)	-0.111*** (-4.22)	-0.316 (-2.47)	-0.266*** (-3.69)	-0.204*** (-2.54)	
β_{t-1}^{HK}	-0.268*** (-9.77)	0.028 (1.01)	-0.020 (-0.78)	-0.202 (-1.57)	0.089 (0.22)	-0.097 (-1.20)	
β_{t-2}^{HK}	0.033 (1.34)	-0.018 (-0.76)	0.022 (0.94)	-0.185 (-1.54)	-0.014 (-1.02)	0.035 (0.47)	
β_{t}^{SH}	0.019 (1.15)	-0.071*** (-2.44)	-0.036** (-2.05)	0.160 (0.92)	-0.124* (-1.71)	-0.023* (-1.72)	
β_{t-1}^{SH}	0.016 (0.95)	0.040 (1.29)	0.002 (0.41)	-0.204 (-1.19)	-0.063 (-0.81)	0.024 (0.44)	
β_{t-2}^{SH}	-0.016 (-0.99)	-0.006 (-0.21)	0.008 (0.17)	-0.065 (-0.38)	0.068 (0.88)	0.006 (0.13)	
Adj. R^2	10.78%	10.10%	16.72%	3.87%	3.29%	9.20%	
Chow	10.62***			10.06***			

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

Table 4.13 contains the parameter estimates from the regression model in equation (1) and the corresponding Chow test statistic for the following two sub periods: prior to 2003 and post 2003, or three sub-periods: prior to 2000, 2000-2003, post 2003, for the ADRs where applicable. The Chow tests are statistically significant at less than 1% level for all ADRs. It clearly indicates multiple structural shifts around the year of 2000 and 2003 during the whole sample period, which causes the regression parameters to significantly differ in magnitudes from one period to another. This points to the obvious unreliability of pooled estimates since the regression coefficients seem to be non-stationary. The parameter estimates for each sub period provide a narrative for a dynamic relation between returns spread and the market indices.

The over arching theme from table 4.13 is that the regression coefficients vary more with time than with respect to models. First, due to different listing history of these ADRs, some ADRs listed before 2000, some listed after 2000, so the observation of the structural change around 2000 is limited. However, for the seven ADRs which were listed before 2000, two in the portfolio I (namely CHL, GSH) and five in the portfolio II (namely, CEA, ZNH, HNP, SHI, YZC), we find except for CHL, all the other six ADRs have a drop in their correlation coefficients with contemporaneous US market return during the sub-period of 2000-2003. This finding demonstrates our expectation as selecting 2000 to account for the US market collapse around 2000. It shows when the US market had negative shock, the ADRs' comovement effect with the US market decrease.

Second, we find the comovement effect with the underlying Hong Kong market varies to a fairly large extent. We show that in portfolio I, three ADRs, namely, ACH, CBA, and PTR, do not have significant comovement effect with the Hong Kong market before 2003. And the other three ADRs in portfolio I (GSH, CHU, and CHL) slightly decrease in the correlation coefficients with Hong Kong market return after 2003. For portfolio II, three ADRs (CEA, ZNH, and YZC) have a decreasing trend in the comovement effect with Hong Kong market return, while the other three ADRs (SNP, HNP, and SHI) have an increasing trend in the comovement effect with Hong Kong market return. We do not observe a clear changing movement in the comovement effect with Hong Kong market return around 2003, in spite of our expectation of an indirect impact transferring from China's stock market to the Hong Kong stock market.

Third, for the portfolio II, we include Shanghai market return in their regression functions. And we find the comovement effect with Shanghai market index exists only contemporaneously, which may suggest the impact from Shanghai market diminish quickly. For the six ADRs in portfolio II, we find except for ZNH, the other five of them have significant negative coefficient with the contemporaneous comovement effect with Shanghai index. Further, two of these ADRs (HNP and SNP) have significant correlation with Shanghai market only after 2003, and two of them (SHI and YZC) have significant correlation with Shanghai market after 2000, and the coefficients for the sub-period 2000-2003 are bigger than that for the sub-period post-2003, finally, one ADR (CEA) has significant correlation coefficient with

Shanghai market only for the sub-period 1997- 2000. These findings are isolated, so that it is difficult to claim whether the innovations of the China's stock market have a clear pattern of impact on the Chinese ADRs.

From this structural change test, we find the comovement effects with the US market dominate in each sub-period, and most of these ADRs have a shrink in the comovement effect with the US market for the period of 2000-2003, this justifies our expectation about the US market collapse in 2000. However, the impacts from the innovations of China's domestic market do not show a clear pattern for the period of post-2003. This may suggest insignificant market impact either directly from Shanghai or indirectly from Hong Kong.

4.6. Conclusion

We study returns and returns spreads on Chinese ADRs listed with primary listing in Hong Kong stock exchange. We compare returns and return distributions on the Chinese ADRs and their underlying H shares, by applying both the location-sensitive statistical tests and distribution-sensitive statistical tests, we find although we cannot reject the equality in the locations (means, medians) of two securities return series, we reject the equality in the distributions for most of the ADRs in our sample. This finding is consistent with both Kato et al. (1991) and Rabinovitch et al (2003), though these two important papers make contradictory conclusions with regard to the issue of the Law in the ADRs. Recently developed theory about the financial market, such as

Copula weighted portfolios, indicate some international financial institutions, such as hedge funds, can gain profit in the higher moments deviation of the cross-listed securities, so our finding is of importance for the internationally investment strategies.

Further we find the return spread (price differential) of the Chinese ADRs is affected by the comovement effect. Our findings are not only consistent with that of Gagnon and Karolyi (2004) who reported the significant *contemporaneous* comovement effect, but also contribute to the literature that we in addition find *lagged* comovement effect. Our finding also supports Kim et al. (2000) who found the ADRs response to the innovation of the S&P 500 is large, positive and highly significant at the day 0, and followed by a large, significant negative price response on day 1.

One of the interesting findings is that two portfolios are clearly different in terms of the comovement effects, as well as return distributions. The ADRs in portfolio II which list A shares in Shanghai have lower returns than the ADRs in portfolio I. We believe it is due to A shares listing increased shareholder base that decreased the ADRs return, as explained by the 'Investors' Recognition Hypothesis' by Merton (1987), who argued that expected return of the firm's stock decrease with the size of the investor's shareholder base this justifies the implicit impact of the domestic market. On the other hand, unlike the ADRs in portfolio I, return spreads of the ADRs in portfolio II are all negatively skewed, this indicates two portfolios have structural break in terms of return distribution. Further, the ADRs in portfolio I have larger magnitude of the comovement effect than the ADRs in portfolio II.

Finally, we have also investigated illiquidity effect and liquidity risk on the return spread. We measure liquidity risk by trading volume and illiquidity by Amihud's ILLIQ. The illiquidity effect is less significant than the liquidity risk, and though we find liquidity is one of the factors in determining return spread, it is a secondary effect compared to the comovement effect.

Chapter 5

Volume-Volatility in Dual Markets: Lessons from the Chinese ADRs

5. 1. Introduction

The findings of previous chapters lead to a further investigation on the price difference between the Chinese ADRs and their identical underlying H shares in this chapter. We have shown the different prices of two securities can be explained by the systematic comovement effect of the local market, and our findings are consistent with the findings of Gagnon and Karolyi (2004). The comovement effect is caused by information-based factors such as the degree of synchronization of the common movement between the ADRs market and the underlying market, the existence of asymmetry of information between insiders and other shareholders.

From the viewpoint of market microstructure theory, price is a function of the intensity of information arrivals. As posited in O'Hara (1995:153) that 'prices are conditional expected values, the price at each point reflects all publicly available information'. Anderson (1996) stated that 'price movements are caused primarily by the arrival of new information and the process that incorporates this information into market prices'.

For the Chinese ADRs and their underlying H shares, due to the non-synchronistic trading hours, the new information, which is expected to be equally affecting the price of two securities, however arrives at two markets at different times, thus the price adjustment process to the new arrival of information may differ between the two markets. And the reason of the different price adjustment process may stem from the non-synchronistic trading hours to the issues of the dynamic information flow across markets, and how market participants learn from market information.

There are a number of factors which would take part in this price adjustment process, for example ‘the trader’s risk preferences and endowments, the nature and extent of uncertainty, and the market structure itself’ (O’Hara, 1995: 155). We believe any differences of these factors between the two markets could lead to various price adjustment processes. As analysed and reported in chapter 2, the market microstructures of the NYSE and SEHK are different. NYSE is a hybrid market with combining dealer and auction trading mechanisms where market makers play a very important role in providing liquidity. On the contrary, SEHK has adopted a continuous auction trading mechanism where individual traders put trading orders through an electronic trading board, namely Automatic Order Matching and Execution System (AMS), and very limited numbers of market makers exist in the market. Different trading mechanisms of two markets give rise to different kinds and proportions of market participants, for example, in the NYSE, market participants are composed of informed traders, market makers, and uninformed traders, both informed traders and uninformed traders would trade with market makers; in the SEHK, however, market participants are mainly either informed traders or uninformed traders who trade among themselves through electronic trading board. The informed traders have private information about the stock’s future dividends, while the uninformed traders extract information from realized dividends, prices and public signals. The uninformed investor trade for non-informational reason and this non-informational trading are also known as noise trading. The different risk preference and endowments of the investors in the US and Hong Kong market leads to differences in noise trader risk in two markets which hampers professional arbitrageurs to earn arbitrage profit between two securities, and it gives rise to a persistent price discrepancy between the Chinese ADRs and H shares, which is known as the comovement effect.

From the market microstructure perspective, the price adjustment process is revealed by trading volume, as Epps and Epps (1976) argued that increase in trading volume is associated with the extent to which traders disagree on a stock's price which leads to price change, therefore the price variability-volume relation arises. In chapter 4, we have reported a positive relation between contemporaneous relation between trading volume and return, and we have explained that it occurs as trading volume may contain the information of liquidity risk as suggested by Karpoff (1987) and Johnson (2007).

As we have analysed above that long term mispricing persists between the Chinese ADRs and the underlying H shares may be due to the different market microstructure of the two markets which employ two kinds of trading mechanisms and involve heterogeneous investors, these factors lead to price adjusting in different process. Since the literature suggests that trading volume is one important factor in conveying the price adjustment process, we believe different return volatility-volume relation between the two markets would give deeper insights for the ADRs' mispricing. Therefore, a market microstructure perspective to investigate the volume-volatility relation would make an important contribution to the literature of the ADRs' arbitrage.

The relationship between trading volume and return volatility has received considerable attention in the finance literature. In terms of new information arriving into the market and its impact on the volume volatility relation, the two existing hypotheses- the Mixture of Distributions Hypothesis (MDH) and Sequential Information Arrival Hypothesis (SIAH) – make contrdictory predictions. On the one hand, the Mixture of Distributions Hypothesis (MDH) originally proposed by Clark (1973) predicts a positive relation between contemporaneous stock return variance and trading volume. On the other hand, the Sequential Information Arrival Hypothesis (SIAH) proposed by Copeland (1976) and Jennings et al (1981) suggests a positive bidirectional causal relation between changes in stock prices and trading volume.

Prior empirical studies on the volatility-volume relation found evidence on a contemporaneous as well as a lead-lag causality relation between volume and conditional return volatility. Lamoureux and Lastrapes (1990), Anderson (1996), and Girard and Biswas (2007) found evidence in support of a contemporaneous volume volatility relation as predicted by the MDH for the US stock market. Omran and McKenzie (2000) found similar evidence for the UK stock market; Pyun et al (2000) for the Korean stock market; and Bohl and Henke (2003) for the Polish stock market.

With regard to SIAH, although empirical evidence generally supports causality between trading volume and returns volatility, such evidence on the direction of causality is mixed. Gallant et al (1992), Gervais and Mingelgrin (2001), and Darrat et al (2003, 2007) provide strong evidence for a positive lead lag relation between volume and absolute price changes in the NYSE but find the causality relation only exists from volume to return volatility. On the contrary, Hiemstra and Jones (1994) and Brooks (1998) found the presence of *bidirectional* Granger causality between daily stock returns and changes trading volume in the US stock market. Silvapulle and Choi (1999) find similar evidence from the Korean stock market.

As we can see from the literature, the majority of empirical researches on the volume-volatility relations cited above focus on single country market indexes and we know of no published empirical study on the volume-volatility relations of individual securities traded in multiple markets. We examine the relation between daily information flow as measured by trading volume and the conditional volatility of returns of 15 individual Chinese ADRs listed on the NYSE and of their corresponding primary listings on Hong Kong stock markets (SEHK), the total number of stocks in our sample is 30.

The primary objective of our study is to compare and contrast the volume-volatility relations of the Chinese ADRs and those of their underlying shares. We test if a contemporaneous correlation exists between return volatility and volume as predicted by MD hypothesis. We then examine the lead–lag relations between volume and volatility using appropriate Granger-causality tests to test the predictions of the alternative SIA hypotheses. We also test the competing theories put forth in the literature as explanations for the presence of GARCH effects in stock return volatility.

In terms of modeling, we use a bivariate GARCH model in a VAR framework where return volatilities for ADRs and their underlying securities are jointly determined by volume and volatility in each market.

This chapter proceeds as follows: section 5.2 gives the literature review on the two hypotheses about volume-volatility relationship; section 5.3 introduces the research methodology and hypothesis development; section 5.4 contains data description and the empirical results; section 5.5 is the conclusion.

5.2. Literature Review

5.2.1 The Mixture Distribution Hypothesis

The Mixture Distribution Hypothesis indicates securities' return is not drawn from a single probability distribution but from the joint distribution of volatility and volume upon the rate of information arrival instead. The important papers include Clark (1973), Epps and Epps (1976), Tauchen and Pitts (1983), Lamoureux and Lastrapes (1990), and Andersen (1996).

Clark (1973) intended to model the stochastic process of the cotton futures price series and tried to explain why the probability distribution of the daily price change is leptokurtic. The secondary finding of his paper is 'the variance of price change is a combination of price changes on individual trades, and a deficiency of volume at high price changes, caused by traders moving their expectations in unison'.

Clark (1973) used this model $\sigma^2 \big| v_t = B v_t^{\beta}$ to investigate the curvilinear relationship between conditional price variance ($\sigma^2 \big| v_t$) and trading volume (v_t) and found quite high correlation between these two variables by applying the model in the cotton futures market. He explained that in the cotton futures market, if the information is asymmetric between informed and uninformed traders, then large price changes would be coincident with high volumes.

Epps and Epps (1976) considered a within-day trading model to explain the price-formation price where the changes in log price and transaction volume are stochastic dependent. Their model is similar to Clark's (1973) and implied that the conditional variance of the price change is a function of trading volume. Epps and Epps (1976) also reported empirical evidence by applying their model to examine 20 NYSE-listed common stocks based on the transaction during the month of January, 1971, they found positive correlation between $\log(\sigma^2 \big| v_t)$ and $\log(v_t^2)$.

Tauchen and Pitts (1983) derived a joint probability distribution of the price change and the trading volume in their empirical study of T-bill futures market. The model of Tauchen and Pitts (1983) was different with the models of Clark (1973) and Epps and Epps (1976) in several ways, first, both Clark's model and Epps and Epps' model required to specify in advance by nonlinear regression the functional form of the conditional expectation $E(\sigma^2 \big| V)$; second, neither of these two models considered growth in the size of speculative markets as experienced by many of the new financial future markets. Therefore, Tauchen and Pitts considered a setting with *J* active traders who take long or short position in a single futures contract, and the price adjust from the $(i\text{-}1)^{st}$ to the i^{th} within day Walrasian equilibrium. In their model, trading volume is a function about the absolute difference between the change of Walrasian equilibrium price and the current market price, and the variance of the change of the current market price and the variance of trading volume include common variable which is related to *J*, the number of the market traders. And finally, they reported the covariance of the change of the market price square and trading volume is greater than 0, namely, $Cov(\Delta p^2, V) > 0$, where Δp^2 is the change of the market price square, V is trading volume. Like Clark (1973) and Epps and Epps (1976), Tauchen and Pitts (1983) examined the relation between $\log(\Delta p^2{}_t)$ and $\log(V_t)$ by using OLS estimation, they found positive relation between these two variables, at the same time, they reported that the error term of this regression function is heteroscedasticy. These findings suggested the model of Autoregressive Conditional Heteroskedasticity (ARCH) to be used in investigating the volatility-volume relation in the following studies.

Unlike Clark (1973), Epps and Epps (1976), and Tauchen and Pitts (1983) who used the variance of the change of log price to capture the volatility of return, Lamoureux and Lastrapes (1990) employed the Generalized Autoregressive Conditional Heteroskedasticity (ARCH) to model the return volatility. This paper studied the relation between daily return volatility and volume based on a sample of 20 actively traded common stocks in the US stock market with the sample period of one year. Their empirical model was $h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1} + \alpha_2 h_{t-1} + \alpha_3 V_t$, where h_t is the GARCH term from the fitting AR (*n*) model, and V_t is trading volume. Lamoureux and Lastrapes (1990) found a significant relation between h_t and V_t, and a substantial reduction in volatility persistence when volume is included, which they explained as the contemporaneous trading volume containing the information about the variance of the stock return.

Andersen (1996) modified the MDH model into a full dynamic representation by incorporating a specific stochastic volatility process for the information arrivals, unlike previous MDH approaches which applied an identical joint probability distribution of price changes and trading volume over each interval, Andersen (1996) constituted a dynamic joint distribution of price changes and volume during each equilibrium phase. He described a dynamic market specification in a microstructure framework where three distinct groups of traders, namely, specialists, informed traders, and uninformed traders, kept revising their price estimations upon receiving either public or private information over time. Specifically, the daily return is conditionally normal with variance which reflects the intensity of information arrivals, namely, $R_t|K_t \sim N(0, \sigma^2 K_t)$ where R_t is daily return, K_t stands for the intensity of information arrivals. $V_t|K_t \sim Po(m_0 + IK_t\mu)$ is the specification of the dynamic trading volume, which is based on a Poisson approximation incorporating both noise component (m_0) and informed component ($IK_t\mu$). Therefore, the covariance of the return variance and trading volume is greater than zero, namely, $Cov(R_t^2, V_t) > 0$. Andersen (1996) also reported empirical evidence of contemporaneous characterization of the return-volume relation as suggested by MDH based on a sample of 5 major common stocks traded on the New York Stock Exchange in a time period of 18 years.

Omaran and McKenzie (2000) followed the same methodology as Lamoureux and Lastrapes (1990) and examined the common stocks in the UK market. Their sample included the daily returns and volume on 50 British companies during the period from January 1988 to February 1994. The model they tested was exactly the same as the model of Lamoureux and Lastrapes (1990) that $h_t = \alpha_0 + \alpha_1\varepsilon_{t-1} + \alpha_2 h_{t-1} + \alpha_3 V_t$, and their findings were consistent with that of Lamoureux and Lastrapes (1990) that the coefficient of volume was highly significant for all companies and volatility persistence became negligible for most stocks when trading volume was involved. However, contradicting Lamoureux and Lastrapes (1990); they argued that GARCH effects cannot be explained by the serial dependence in volume of trade, because the structure of the model itself that h_{t-1} is itself a function of V_{t-1}. Moreover, V_t is highly correlated with its past, $V_{t-1};V_{t-2};\ldots;$ which can lead to a multicollinearity problem between the explanatory variables used, h_{t-1} and V_{t-1}.

Similar empirical evidence also include Pyun, Lee, and Nam (2000) and Bohl and Henke (2003). Both of these two papers followed the approach of Lamoureux and Lastrapes (1990) and reported consistent results with Lamoureux and Lastrapes (1990). Pyun, Lee, and Nam (2000) studied weekly returns of stocks listed on the Korean Stock Exchange during the 5 year period between 1990 and 1994. Bohl and Henke (2003) consider daily returns and the trading volume for 20 stocks listed at the Warsaw Stock Exchange (WSE) over the period from January, 1999 to October, 2000.

5.2.2 The Sequential Information Arrival Hypothesis

The contradictory theory to MDH is the Sequential Information Arrival Hypothesis (SIAH) of Copeland (1976), Jennings, Starks and Fellingham (1981), Gallant, Rossi and Tauchen (1992), Hiemstra and Jones (1994), Gervais and Mingelgrin (2001), and Darrat, Rahman and Zhong (2003). The main difference between the SIAH and the MDH is that the MDH assumes all traders have homogeneous response to new information, while the SIAH assumes new information is disseminated sequentially to traders and in a random order, and traders responds to the new information heterogeneously. The traders adjust their positions and expected market price based on the observed market price and their own private information. As such, before a final equilibrium is attained, a series of sequential equilibriums as intermediates contain information on past volatility data that can be used to forecast trading volume, or vice versa. Due to the lagged sequential information flow absolute stock returns could have predictive power for current trading volume and vice versa, which imply bidirectional causality between volume and volatility.

Copeland (1976) developed a theoretical model to describe a setting where N traders possessed an identical set of information, but each of them would shift their demand curve in different magnitude and direction. Further, he considered three cases with short sale binding, namely, all traders were pessimistic, all traders were optimistic, and traders were mixture of pessimistic and optimistic. His model had some strict assumptions such as the percentage of optimistic traders was symmetrically distributed with the mean of 0.5, and the short sale constraint was binding that the uninformed traders would not sell more than they have. Since all traders would shift their demand curve differently, Copeland developed sequential equations of equilibrium price and the corresponding volume at different stages between the original and the final equilibria. Upon these assumptions, the model predicted a positive correlation between absolute price change and trading volume at sequential equilibrium.

Jennings, Starks and Fellingham (1981) specified a particular dynamic price adjustment process that it assumed that only one trader observed the information initially. This trader interpreted the news, revised his beliefs, and traded to arrive at a new optimal position. The next investor became informed based on this new equilibrium, and after a similar sequence of events, a second temporary equilibrium was achieved. This process continued until all traders were informed and results in a series of momentary equilibria. When the last trader receives the information, the market reaches a final equilibrium. The outcome of this series of events was the generation of a sequence of transaction volume. Jennings et al (1981) modified the model of Copeland (1976) by considering informed and uninformed traders and a margin requirement as a realistic restriction on short sales. Their model also theoretically predicted a positive correlation between the absolute price change and trading volume.

Gallant, Rossi and Tauchen (1992) undertook an empirical investigation of the dynamic interrelationships among price and volume movements of the US stock market index. Their sample was composed of the daily closing value of the S&P composite stock index and the daily volume of shares traded on the NYSE with the time period from 1928 to 1987. Their results suggested that large price changes lead to increases in both the mean and variability of the volume.

Gervais and Mingelgrin (2001) investigated the high-volume return premium. The high-volume return premium is such kind of volume-return relationship that periods of high trading volume tend to be followed by periods of positive excess returns, whereas periods of low volume tend to be followed by negative excess returns. Their findings also confirmed that a positive relation exists between the average cumulative returns and trading volume, and that the shocks in the volume contain information about future returns.

Hiemstra and Jones (1994) empirically studied both linear and non-linear causality relation between volume and return. Their sample included daily return and trading volume data of Dow Jones stock index for the time period from 1915 to 1990. They employed both traditional linear Granger causality test and the modified Baek and Brock test which is a non-parametric Granger causality test. The traditional linear Granger causality test detected unidirectional Granger causality from stock returns to trading volume. In contrast, the modified Baek and Brock test provides evidence of significant nonlinear bidirectional Granger causality between stock returns and trading volume.

Silvapulle and Choi (1999) used daily Korean Composite Stock Index data to study the linear and non-linear Granger causality between stock price and trading volume. They followed the modified Baek and Brock test by Hiemstra and Jones (1994) and reported significant bidirectional causality between trading volume and the return volatility predicted by the GARCH (1, 1) model.

Darrat, Rahman and Zhong (2003) examined the contemporaneous correlation as well as the lead–lag relation between trading volume and return volatility. Their sample consisted of all stocks comprising the Dow Jones industrial average (DJIA) from April 1, 1998 to June 30, 1998. They used 5-minute intraday data and measure return volatility by the exponential generalized autoregressive conditional heteroscedasticity method (EGARCH). They applied Granger causality test to study both contemporaneous and lead-lag relation on a bivariate vector autoregression model (VAR). Their findings strongly supported the SIAH but found little evidence of MDH.

5.3. Research methodology and hypothesis development

5.3.1 Model selection for return volatility

The variance of the price change was the proxy to stand for return volatility in the earlier literature of volume-volatility relation, such as Clark (1973), Epps and Epps (1976), and Tauchen and Pitts (1983). However, these papers all reported that the error term of the OLS estimated regression function of $\log(\Delta p^2_t)$ on $\log(V_t)$ is heteroscedasticy. Since Engle published his remarkable paper about Autoregressive Conditional Heteroskedasticity (ARCH) model in 1982, Lamoureux and Lastrapes (1990) turned to use the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) to model the return volatility. Thereafter, GARCH model became widely used in the study of return volatility-volume relation. Further, Kim and Kon (1994) compared three models: GARCH, Exponential GARCH (EGARCH), and Threshold GARCH (TGARCH), they found that both EGARCH and TGARCH models could capture the conditional heteroscedasticity and the asymmetric leverage effect of the return series fairly well, in addition, the individual stock's return is in favor of TGARCH model, while the EGARCH model is more likely a proper description for the stock index return.

In this chapter, we will examine the heteroscedasticity of return series by applying Ljung-Box test. And then follow the approach of Kim and Kon (1994) and Giraid and Biswas (2007), who used two asymmetric GARCH methods, namely, the Threshold GARCH and Exponential GARCH, to model stock return volatility. These two models capture asymmetric characteristics of the positive/negative shock (namely good/bad news). Particularly, Threshold GARCH model is able to involve positive shock where the error is above the *threshold* value of zero, and negative shock where the error is below the *threshold* value of zero. Generally, negative shocks have a greater effect on conditional volatility than positive shocks of the same magnitude, which is known as 'leverage effect' that volatility clustering in asymmetric pattern. The reason we apply these two asymmetric GARCH models is because 'leverage effect' is commonly observed in equity markets that volatility is higher in a falling market than it is in a rising market. The volatility response to a large negative return is often far greater than it is to a large positive return of the same magnitude.

Apart from 'leverage effect', the Threshold GARCH and Exponential GARCH models also account for two other characteristics. The first is volatility clustering which implies large (small) price changes tend to follow large (small) price changes. The second characteristic is fat tail which is characterized as leptokurtosis and skewness, and both of which indicate departure from normality of the data, and both of which are regarded as the particular feature of daily stock returns.

Further, these two models allow for a general probability density function (i.e., generalized error distribution, GED), which nests the normal distribution along with several other possible densities. Bollerslev et al. (1992) noted that imposing the normality assumption on the GARCH model could bias the estimates.

Finally, many GARCH models have to place non-negative constraints on the parameters to avoid generating negative variances, even though this may unduly restrain the model dynamics. The EGARCH model eliminates the need for such constraints by formulating the conditional variance in logarithmic terms.

Although Kim and Kon (1994) argued individual stock's return is fond of TGARCH rather than EGARCH, Girard and Biswas (2007) showed there was no preferred one between the TGARCH and EGARCH models. Following Girard and Biswas (2007), we will use both TGARCH and EGARCH model to estimate return volatility process. We give our mean return equation and return volatility equation according to TGARCH model as:

$$R_t = \alpha + \sum_{r=0}^{p} \beta_r R_{t-1} + \varepsilon_t \qquad (1)$$

$$\sigma_t^2 = \alpha + \psi \varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 d_{t-1} + \lambda\sigma_{t-1}^2 \qquad (2)$$

Where R_t is the realized return of the stock, expressed as an AR (p) process with an error term of mean zero and conditional variance σ_t^2. Lags p in AR process is selected based on AIC and SBC criteria. The conditional variance σ_t^2 is specified as a function of the mean volatility α, ε_{t-1}^2 which is the lag of the squared residual from the mean equation (the ARCH term) and which provides news about volatility clustering; σ_{t-1}^2 which is the last period's forecast variance (the GARCH term) and finally, the term for capturing the asymmetry $\varepsilon_{t-1}^2 d_{t-1}$. The parameter d_t is a dummy which equals 1 if ε_t <0, and 0 otherwise, so that good news (ε_t >0) and bad news (ε_t <0) are allowed to have different effects on the conditional variance. Good news has an effect of ψ, while bad news has an effect of $\psi + \gamma$. Accordingly, if γ >0, a leverage effect, exists, then bad news has greater effect than good news.

The EGARCH model has the same mean equation as the one of TGARCH model, but is different in the conditional variance equation which is defined in terms of a standard normal variate z_t :

$$\ln\sigma_t^2 = \omega + g(z_{t-1}) + \beta\ln\sigma_{t-1}^2 \qquad (3)$$

Where $g(\cdot)$ is an asymmetric response function defined by $g(z_t) = \lambda z_t + \varphi(|z_t| - \sqrt{2/\pi})$, where $(|z_t| - \sqrt{2/\pi})$ is the mean deviation of z_t since $\sqrt{2/\pi} = E(|z_t|)$[15].

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[15] EGARCH is difficult to use for volatility forecasting because there is no analytic form for the

5.3.2 De-trend Trading volume

Previous papers have reported that trading volume is not stationary and with trend, since we will use vector autoregression (VAR) framework to test Granger causality of volume-volatility relation as suggested by SIAH, it requires the variables in the VAR framework are stationary. Following Lee and Rui (2002) and Girard and Biswas (2007), we de-trend the trading volume series by assuming volume as a deterministic function of time. As reported by Gallant et al (1992), trading volume series is composed of both linear and nonlinear time trend, we include both time and quadratic time trend terms:

$$Vol_t = \alpha + \beta t + \chi t^2 + \varepsilon_t \qquad (4)$$

Where Vol_t represents raw daily trading volume and t is time. For the 15 Chinese ADRs and their underlying shares, the coefficients for both linear and non-linear trend term are significantly different from zero. In the following analysis we will employ trading volume without trend for the 15 Chinese ADRs and their underlying HK shares. The de-trended trading volumes as unobservable information arrival are the residuals from equation (4).

5.3.3 Test MDH

volatility term structure.

Lamoureux and Lastrapes (1990) developed a method to empirically examine the MDH by incorporating trading volume into equation (2), and they argue that if trading volume and return volatility are jointly distributed, then persistence of volatility should become negligible when trading volume is incorporated, and there is a positive relation between return volatility and trading volume. However, Lamoureux and Lastrapes (1990) suggested volume may be endogenous to the system and would cause that "simultaneity bias", so Girard and Biswas (2007) alternatively employed volume with one lag in the variance equation, we follow Girard and Biswas (2007) to test the MDH model as below:

$$\sigma_t^2 = \alpha + \psi \varepsilon_{t-1}^2 + \gamma \varepsilon_{t-1}^2 d_{t-1} + \lambda \sigma_{t-1}^2 + \delta V_{t-1} \quad (5)$$

Where the other terms are same as that in equation (2), V_{t-1} stands for the contemporaneous trading volume after de-trended. According to the MDH, persistence of volatility is measured by $(\psi + \gamma + \lambda)$, if $(\psi + \gamma + \lambda)$ equals one, then current shocks persist indefinitely in conditioning the future variance. It also represents the change in the response function of shocks to volatility per period. And if $(\psi + \gamma + \lambda)$ is greater than one, which implies that the response function of volatility is explosive. Likewise, if $(\psi + \gamma + \lambda)$ is less than one, which implies that the response to volatility shocks declines over time. As demonstrated in Lamoureux and Lastrapes (1990) and Girard and Biswas (2007) that when contemporaneous trading volume is involved, persistence of volatility would disappear, so our null hypothesis is V_{t-1} is not positively correlated with σ_t^2, and $(\psi + \gamma + \lambda)$ will be significantly different from zero.

5.3.4 Test SIAH

The SIAH has been tested by applying Granger causality test, for example, Hiemstra and Jones (1994), Silvapulle and Choi (1999), and Darrat, Rahman, and Zhong (2003). We follow these papers to examine the lead-lag relations between volume and volatility by using Granger causality test. Granger causality means that a lead-lag relationship is evident between variables in a multivariate time series, or one variable happens before and helps to predict another one. According to the SIAH, due to the sequential information flow, lagged trading volume could have predictive power for current absolute stock returns and lagged absolute stock returns could have predictive power for current trading volume. We give the testing model as below:

$$\sigma_t^2 = \alpha_1 + \sum_{k=1}^{p} \beta_k \sigma_{t-k}^2 + \sum_{k=1}^{q} \theta_k V_{t-k} + \varepsilon_{1t} \qquad (5)$$

$$V_t = \alpha_2 + \sum_{k=1}^{m} \delta_k \sigma_{t-k}^2 + \sum_{k=1}^{n} \phi_k V_{t-k} + \varepsilon_{2t} \qquad (6)$$

Where σ^2 is the return volatility and V_t is the de-trended trading volume. In equation (5), if the θ_k coefficients are statistically significant, then inclusion of the past trading volume, in addition to the past volatility, yields a better forecast for the future volatility, and we say volume cause return. Likewise, in equation (6), if return volatility cause volume, the coefficient of δ_k will be significantly different from zero. We use a Granger causality Wald test to test that $\delta_1 = \delta_2 = \ldots = \delta_m = 0$ and $\theta_1 = \theta_2 = \ldots = \theta_q = 0$. Because when we have a large sample, the Wald test can have a better approximate, we do not use Granger causality F test is because F test emphasizes that the errors are normally distributed and the explanatory variables are treated as non-stochastic (Griffiths, Hill, and Judge, 1993: 456).

5.4. Data and empirical results

5.4.1 Data

We use the same data sample as for the sample in chapter 4, which consists of daily prices (see the descriptive statistics in Table 4.3) and trading volumes (see the descriptive statistics in Table 4.11) on the Chinese ADRs listed on the US stock exchanges and their corresponding underlying securities listed on the Stock Exchange of Hong Kong (SEHK). We compute continuously compounded returns on the underlying stocks listed at SEHK (Hong Kong Stock Exchange) and their corresponding ADR listings in NYSE as $r_t^i = \ln(P_t^i / P_{t-1}^i)$ where P_t^i denotes closing price of security *i* on day *t*.

5.3.2 Results of model selection for return volatility

So in the following, we analyze the heteroscedasticity of return series. In statistics, a sequence or a vector of random variables is heteroscedastic if the random variables have time-varying variances. Heteroskedasticity does not cause OLS coefficient estimates to be biased. However, the variance (the standard errors) of the coefficients tends to be underestimated, increasing the t-ratio and is probably to make insignificant variables appear to be statistically significant. Many financial return series display volatility clustering, that is autoregressive conditional heteroscedasticity, and which implies a strong autocorrelation in squared returns, so we utilize Ljung-Box test to examine if return and squared return series are serial correlated, an autocorrelated time series means the covariance is not independent of time. The Ljung-Box Q statistic is calculated based on the sample autocorrelation, under the null hypothesis of zero autocorrelation, Q will have an asymptotic χ^2 distribution with certain degree of freedom, the Ljung-Box Q(6) and Q(12) statistics for return and squared return autocorrelations are reported in Table 5.1.

Table5.1. The Ljung-Box Q statistics

(Q(6) and Q (12) are Ljung-Box statistics for returns distributed as χ^2 with 6 and 12 degrees of freedom respectively, $Q^2(6)$ and $Q^2(12)$ Ljung-Box statistics for squared returns distributed as χ^2 with 6 and 12 degrees of freedom respectively.)

Symbol	Market	Q(6)	Q(12)	$Q^2(6)$	$Q^2(12)$
ACH	NYSE	12.99**	15.81	26.54***	49.60***
	SEHK	11.54**	20.19*	24.46***	78.80***
CBA	NYSE	7.32	14.39	23.19***	29.22***
	SEHK	3.33	7.40	82.26***	150.91***
LFC	NYSE	10.48	13.21	87.04***	163.05***
	SEHK	6.53	8.02	81.74***	95.75***
CHL	NYSE	6.88	10.76	94.35***	179.26***
	SEHK	21.94***	31.60***	210.31***	341.12***
CHA	NYSE	3.29	7.18	83.58***	117.22***
	SEHK	9.81	12.57	34.44***	83.56***
CEO	NYSE	1.97	3.32	20.03***	43.90***
	SEHK	7.77	9.28	17.90***	66.12***
GSH	NYSE	23.98***	36.22***	198.43***	259.87***
	SEHK	7.76	15.17	102.96***	174.17***
PTR	NYSE	5.97	14.73	99.02***	222.16***

	SEHK	13.41**	16.08	56.84***	103.35***
CHU	NYSE	7.31	11.37	17.39***	38.57***
	SEHK	4.54	6.65	28.73***	67.07***
CEA	NYSE	8.86	11.49	73.39***	144.02***
	SEHK	9.63	25.62***	98.77***	155.92***
SNP	NYSE	10.59	20.94**	109.52***	126.16***
	SEHK	15.87***	18.69*	58.43***	103.74***
ZNH	NYSE	3.52	13.63	71.63***	119.69***
	SEHK	5.88	16.36	71.65***	174.19***
HNP	NYSE	8.81***	11.84	150.50***	313.92***
	SEHK	18.51***	21.30**	67.00***	223.88***
SHI	NYSE	6.85	11.24	123.89***	294.58***
	SEHK	1.57	9.67	204.25***	489.49***
YZC	NYSE	8.11	13.53	24.26***	41.68***
	SEHK	9.43	12.10	125.96***	179.82***

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

Data presented in Table 5.1 indicates that only 1 out of 15 ADRs have significant autocorrelation in both 6 and 12 orders; 4 out of 15 HK shares have significant autocorrelation in both 6 and 12 orders. While the significant Ljung-Box test statistics Q^2 (6) and Q^2 (12) indicate the presence of conditional heteroscedasticity for all ADRs and their underlying shares. These findings justify the use of GARCH modeling (Bollerslev, 1986), which allows for conditional variance in the returns.

Next, following Kim and Kon (1994) and Giraid and Biswas (2007), we use TGARCH to model return volatility and examine the ‘leverage effect’; we report the coefficients of the ‘good news’ and ‘bad news’ respectively. We also apply EGARCH as comparison with the TGARCH model, and provide likelihood ratios of both models in Table 5.2.

Table 5.2. Volatility persistence without volume

Symbol	Market	ε_{t-1}^2	$\varepsilon_{t-1}^2\, d_{t-1}$	σ_{t-1}^2	LL1	LL2
ACH	NYSE	0.058(12.13)***	0.003(0.39)	0.581(27.20)***	2508	2498
	SEHK	0.071(18.74)***	-0.002(-0.50)	0.558(29.36)***	2381	2375
CBA	NYSE	0.147(51.33)***	0.002(0.51)	0.421(39.75)***	3178	3171
	SEHK	0.103(57.01)***	-0.021(-7.68)***	0.383(32.97)***	3017	3012
LFC	NYSE	0.133(13.97)***	0.057(4.38)***	0.494(21.05)***	1733	1730
	SEHK	0.046(9.90)***	0.019(2.82)***	0.530(19.70)***	1728	1722
CHL	NYSE	0.091(25.11)***	-0.0046(-0.87)	0.537(37.66)***	4836	4827
	SEHK	0.254(67.60)***	0.0005(0.10)	0.423(48.88)***	4897	4891
CHA	NYSE	0.121(22.70)***	0.036(5.11)***	0.536(31.39)***	2476	2474
	SEHK	0.083(13.67)***	0.014(1.75)*	0.506(22.20)***	2398	2392
CEO	NYSE	0.076(36.45)***	-0.0002(-0.06)	0.472(28.47)***	1631	1633
	SEHK	0.069(18.77)***	0.043(8.22)***	0.329(14.00)***	1562	1564
GSH	NYSE	0.288(78.80)***	0.073(11.45)***	0.352(45.00)***	5659	5645
	SEHK	0.203(45.92)***	-0.009(-1.52)	0.463(45.20)***	5356	5346
PTR	NYSE	0.139(38.04)***	0.019(3.81)***	0.424(32.13)***	3844	3844
	SEHK	0.113(22.39)***	0.048(6.78)***	0.400(23.81)***	3857	3855
CHU	NYSE	0.024(6.49)***	0.0089(1.66)	0.470(21.61)***	3345	3348
	SEHK	0.106(51.75)***	-0.027(-8.41)***	0.307(23.96)***	3435	3437
CEA	NYSE	0.220(82.14)***	-0.011(-2.27)**	0.456(56.69)***	4674	4662
	SEHK	0.314(53.66)***	0.001(0.22)	0.453(49.39)***	4343	4297
SNP	NYSE	0.050(26.64)***	-0.029(-10.93)***	0.491(26.73)***	3466	3465
	SEHK	0.009(40.76)***	-0.018(-50.82)***	0.355(25.18)***	3437	3435
ZNH	NYSE	0.10(20.29)***	0.111(16.91)***	0.627(56.12)***	4046	4012
	SEHK	0.156(56.22)***	-0.010(-2.62)***	0.446(46.06)***	3867	3846
HNP	NYSE	0.200(45.53)***	0.041(6.56)***	0.415(38.26)***	4703	4688
	SEHK	0.196(45.96)***	0.020(2.95)***	0.406(32.77)***	4251	4231
SHI	NYSE	0.176(53.94)***	0.001(0.19)	0.545(58.46)***	5947	5945
	SEHK	0.029(40.93)***	-0.053(-44.73)***	0.523(46.56)***	5432	5426
YZC	NYSE	0.271(47.91)***	0.026(4.14)***	0.607(88.71)***	3671	3667
	SEHK	0.063(18.92)***	-0.049(-13.56)***	0.412(22.47)***	3567	3562
Mean	NYSE	0.140	0.022	0.495		
	SEHK	0.121	-0.0029	0.433		
Maximum	NYSE	0.288	0.073	0.627		
	SEHK	0.314	0.048	0.558		
Minimum	NYSE	0.024	-0.029	0.421		
	SEHK	0.009	-0.053	0.329		
Significant	NYSE	15	9	15		
	SEHK	15	11	15		
Sig. and	NYSE	15	7	15		

Positive						
	SEHK	15	5	15		

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

In table 5.2, we report LL1 which is the maximum log likelihood attained with the above TGARCH model, and LL2 which is the maximum log likelihood that would have been obtained if EGARCH was utilized. ε_{t-1}^2 and $\varepsilon_{t-1}^2 d_{t-1}$ stand for good news and bad news respectively. σ_{t-1}^2 measures the GARCH effect with one-period lag. The coefficients are estimated based on equation (1) and (2), the lags of R_t is chosen based on SBC and AIC.

$$R_t = \alpha + \sum_{r=0}^{p} \beta_r R_{t-1} + \varepsilon_t \qquad (1)$$

$$\sigma_t^2 = \alpha + \psi \varepsilon_{t-1}^2 + \gamma \varepsilon_{t-1}^2 d_{t-1} + \lambda \sigma_{t-1}^2 \qquad (2)$$

These results indicate the following: *a*) All Chinese ADRs and their underlying HK shares have significant coefficient of 'good news' (ε_{t-1}^2). The coefficients of ε_{t-1}^2 range from 0.024 (CHU) to 0.288 (GSH) for ADRs, while range from 0.009 (SNP) to 0.314 (CEA) for HK shares.

b) With regard to reflection on 'bad news', the ADRs on the NYSE have different pattern with the underlying shares on the SEHK, the average coefficient is positive for ADRs whereas negative for HK shares, and the number of significant and positive coefficient of ADRs is more than that of the HK shares. Which suggests the investors in the two stock markets differ in the sentiment to 'bad news'. On the NYSE the leverage effect of 'bad news' is much bigger than the investors on the SEHK, which imply the US investors are more sentimental to ‘bad news’.

This finding is interesting, and we find supportive evidence from recent published paper. Arquette et al (2008) compared the price of the Chinese stocks listed in Shanghai with the price of the same firms but listed in Hong Kong and the US. They found the price differential is significantly determined by the investors’ sentiment which is captured as the company P/E ratio in each market. On the other hand, in chapter 4, we test the comovement effect on the Chinese ADRs mispricing, we find the US investors over react to the US stock market index that is also demonstrated by Kim et al (2000). These findings may be the evident of ‘investors’ sentiment’ hypothesis that stock price is a function of ‘investors’ sentiment’ and the US investors are more pessimistic than the other.

Further, the different reflections with ‘bad news’ in the US and HK market justifies the earlier conclusion in chapter 4 that the inequality distribution of the returns of the Chinese ADRs and their underlying HK shares.

c) The persistence of conditional volatility of the ADRs on the NYSE is higher than that of the HK shares on the SEHK; and we also find similar evidence from the published paper. Xu and Fung (2002) studied price discovery and volatility spillover effect of the Chinese ADRs. Using the bivariate GARCH model, they found the coefficients of the ADRs’ return volatility are higher than that of the H shares’ return volatility. So they concluded that the Chinese ADRs listed on the NYSE play a bigger role in volatility spillover.

However, we also find none of the past volatility coefficient ($\psi + \gamma + \lambda$) is close to one for the ADRs and H shares, which implies that the response to volatility shocks declines quickly over time.

d) As consistent with the findings of Girard and Biswas (2007), we also find slight higher value of likelihood ratio of TGARCH (1, 1) than that of EGARCH (1, 1) for most of the Chinese ADRs. However the likelihood ratios for TGARCH and EGARCH are very close, so we do not carry out the likelihood ratio test.

5.3.3 Results of the test on the MDH

Next, we proceed to test the MDH, we report results in table 5.3.

Table 5.3. Contemporaneous volume-volatility relation test with trading volume.

Symbol	**Market**	ε_{t-1}^2	$\varepsilon_{t-1}^2\, d_{t-1}$	σ_{t-1}^2	V_{t-1} (times 10^4)	**LL1**	**LL2**
ACH	NYSE	0.058(11.98)***	0.0027(0.35)	0.578(26.83)***	0.1(1.28)	2508	2498
	SEHK	0.07(17.72)***	-0.002(-0.46)	0.552(28.73)***	0.1(0.99)	2381	2375
CBA	NYSE	0.148(50.47)***	0.001(0.33)	0.425(39.70)***	-0.3(-2.61)***	3178	3171
	SEHK	0.103(56.16)***	-0.021(-7.70)***	0.383(32.94)***	-0.069(-0.62)	3017	3012
LFC	NYSE	0.128(12.36)***	0.057(4.36)***	0.481(19.00)***	0.3(1.37)	1733	1730
	SEHK	0.040(8.16)***	0.019(2.87)***	0.509(18.63)***	0.4(3.51)***	1728	1722
CHL	NYSE	0.091(24.96)***	-0.0046(-0.85)	0.537(37.66)***	-0.077 (-0.54)	4836	4827
	SEHK	0.254(66.58)***	0.0005(0.10)	0.423(48.62)***	-0.2(-1.10)	4897	4891
CHA	NYSE	0.122(21.65)***	0.036(5.07)***	0.538(31.06)***	-0.074 (-0.77)	2476	2474
	SEHK	0.082(13.03)***	0.014(1.78)*	0.505(22.08)***	0.077 (0.59)	2398	2392
CEO	NYSE	0.076(35.95)***	0.00004(0.01)	0.475(28.59)***	-0.091(-1.97)**	1631	1633
	SEHK	0.067(17.65)***	0.043(8.31)***	0.325(13.90)***	0.2(2.84)***	1562	1564
GSH	NYSE	0.289(78.43)***	0.073(11.58)***	0.355(45.09)***	-0.4(-2.90)***	5659	5645
	SEHK	0.204(45.30)***	-0.009(-1.58)	0.464(44.92)***	-0.1(-0.78)	5356	5346
PTR	NYSE	0.139(37.61)***	0.019(3.81)***	0.423(31.93)***	0.053 (1.18)	3844	3844
	SEHK	0.110(20.86)***	0.048(6.81)***	0.394(23.10)***	0.3(2.36)***	3857	3855
CHU	NYSE	0.021(5.81)***	0.0087(1.63)	0.463(21.20)***	0.2(1.44)	3345	3348

	SEHK	0.106(48.93)***	-0.023(-8.41)***	0.307(23.35)***	-0.03(-0.30)	3435	3437
CEA	NYSE	0.223(80.09)***	-0.011(-2.32)**	0.463(56.34)***	-0.4(-3.78)***	4674	4662
	SEHK	0.317(52.60)***	-0.001(-0.14)	0.454(49.39)***	-0.8(-2.09)***	4343	4297
SNP	NYSE	0.050(26.46)***	-0.029(-10.91)***	0.489(26.60)***	0.039(0.96)	3466	3465
	SEHK	0.009(39.70)***	-0.018(-49.28)***	0.355(24.80)***	0.034 (0.39)	3437	3435
ZNH	NYSE	0.10(20.29)***	0.111(16.91)***	0.627(56.12)***	0.3(1.23)	4046	4012
	SEHK	0.156(56.22)***	-0.010(-2.62)***	0.446(46.06)***	-0.3(-1.75)*	3867	3846
HNP	NYSE	0.199(43.42)***	0.041(6.58)***	0.413(37.30)***	0.2(1.06)	4703	4688
	SEHK	0.196(45.94)***	0.019(2.88)***	0.404(32.23)***	-0.1(-0.95)	4251	4231
SHI	NYSE	0.176(52.62)***	0.001(0.19)	0.545(57.65)***	-0.039(-0.22)	5947	5945
	SEHK	0.029(40.41)***	-0.055(-44.34)***	0.528(46.91)***	-0.1(-4.35)***	5432	5426
YZC	NYSE	0.271(47.73)***	0.025(4.05)***	0.607(88.72)***	-0.2(-1.06)	3671	3667
	SEHK	0.062(18.34)***	-0.047(-13.15)***	0.410(22.37)***	0.5(1.48)	3567	3562
Mean	NYSE	0.145	0.023	0.488	-0.0279		
	SEHK	0.124	-0.002	0.421	-0.0777		
Maximum	NYSE	0.289	0.057	0.627	0.3		
	SEHK	0.317	0.048	0.552	0.5		
Minimum	NYSE	0.021	-0.029	0.355	-0.4		
	SEHK	0.009	-0.047	0.307	-0.8		
Significant	NYSE	15	9	15	4		
	SEHK	15	11	15	6		
Sig. and Positive	NYSE	15	7	15	0		
	SEHK	15	5	15	3		

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

In table 5.3, we report LL1 as the maximum log likelihood attained with the above TGARCH model, and LL2 as the maximum log likelihood that would have been obtained if EGARCH was utilized. ε_{t-1}^2 and $\varepsilon_{t-1}^2 d_{t-1}$ stand for good news and bad news respectively. σ_{t-1}^2 measures the GARCH effect with one-period lag. V_{t-1} measures the contemporaneous volume. The testing model is:

$$\sigma_t^2 = \alpha + \psi \varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 d_{t-1} + \lambda\sigma_{t-1}^2 + V_{t-1}$$

In Table 5.3, we include de-trended trading volume with one lag to test the contemporaneous volume-volatility relation as suggested by MDH. The coefficients of past surprises and innovations only change slightly as compared with the results without contemporaneous trading volume, and we do not find positive and significant correlation between volatility and volume for all ADRs on the NYSE, though we find 3 positive and significant correlations between volatility and volume out of 15 underlying shares on the SEHK. Further, the persistence of volatility do not become negligible after involving trading volume, this is also contradict to the prediction of the MDH. So our finding does not support MDH.

On the other hand, we do not find significant reduction of volatility persistence when the contemporaneous volume series is incorporated, though this evidence is inconsistent with the findings of Lamoureux and Lastrapes (1990), we also find compatible evidence of the findings of Lee and Rui (2002) and Bessembinder and Seguin (1993).

5.3.4 Results of the test on the SIAH

Finally, we report the results of the test on the SIAH in table 5.4. We construct VAR model, as presented in equations (5) and (6) to examine the lead-lag relations between volume and volatility by using Granger causality test, and allow lags up to 5, which is one week length.

Table 5.4. Granger causality between volume and volatility.

Symbol	Market	H0: $V_t \nrightarrow \sigma_t^2$	H0: $\sigma_t^2 \nrightarrow V_t$
ACH	NYSE	2.5e+08(0.000)***	3.2647(0.353)
	SEHK	22.923(0.000)***	1.5686(0.667)
CBA	NYSE	39.806(0.000)***	2.2117(0.530)
	SEHK	32.881(0.000)***	11.442(0.010)***
LFC	NYSE	53.296(0.000)***	2.8106(0.422)
	SEHK	30.73(0.000)***	1.5729(0.666)
CHL	NYSE	53.217(0.000)***	2.4393(0.486)
	SEHK	46.871(0.000)***	3.843(0.279)
CHA	NYSE	39.045(0.000)***	1.3083(0.727)
	SEHK	29.615(0.000)***	0.51276(0.916)
CEO	NYSE	51.299(0.000)***	7.2652(0.064)*
	SEHK	24.56(0.000)***	3.8014(0.284)
GSH	NYSE	32.43(0.000)***	4.8024(0.187)
	SEHK	46.73(0.000)***	4.47(0.215)
PTR	NYSE	36.156(0.000)***	7.2834(0.063)*
	SEHK	65.029(0.000)***	2.3009(0.512)
CHU	NYSE	51.387(0.000)***	7.5388(0.057)*
	SEHK	49.445(0.000)***	2.6485(0.449)
CEA	NYSE	45.671(0.000)***	0.68548(0.877)
	SEHK	44.212(0.000)***	1.244(0.742)
SNP	NYSE	8.2505(0.083)*	2.4604(0.482)
	SEHK	43.708(0.000)***	2.429(0.488)
ZNH	NYSE	4.6738(0.022)**	0.46437(0.927)
	SEHK	11.573(0.021)**	7.3979(0.060)*
HNP	NYSE	15.769(0.003)***	2.3752(0.498)
	SEHK	16.727(0.002)***	2.6326(0.452)
SHI	NYSE	75.659(0.000)***	4.4835(0.214)
	SEHK	56.216(0.000)***	2.1963(0.533)
YZC	NYSE	17.137(0.002)***	2.5422(0.468)
	SEHK	21.072(0.000)***	1.0273(0.795)
Significant	NYSE	15	4
	SEHK	15	2

Note:*** indicates a less than 1% significant level, ** indicates a less than 5% significant level, * indicates a less than 10% significant level

The testing models are:

$$\sigma_t^2 = \alpha_1 + \sum_{k=1}^{p} \beta_k \sigma_{t-k}^2 + \sum_{k=1}^{q} \theta_k V_{t-k} + \varepsilon_{1t} \qquad (5)$$

$$V_t = \alpha_2 + \sum_{k=1}^{m} \delta_k \sigma_{t-k}^2 + \sum_{k=1}^{n} \phi_k V_{t-k} + \varepsilon_{2t} \qquad (6)$$

The null hypothesis is (1) volume does not cause return volatility, so θ_k jointly equals to zero; (2) return volatility does not cause volume, so δ_k jointly equals to zero. Granger causality Wald tests are used, and χ^2 statistics with *p*-value in parenthesis are reported in table 5.4.

Table 5.4 contains results of the set of equations 5 and 6, Granger causality is estimated using the Wald. We find significant causality relation from trading volume to volatility in 15 ADRs and underlying shares in both markets, and find significant causality relation from volatility to trading volume in 4 ADRs and 2 underlying shares. This finding is in support of the SIAH and corroborates Darrat, Rahman, and Zhong (2003).

5.5 Conclusions

In this paper, we use daily return volatility and de-trended trading volume in TGARCH and EGARCH process to incorporate persistence in return volatility. We examine the contemporaneous versus lead–lag relations between volume and volatility in 15 Chinese ADRs on the NYSE and their underlying shares on the SEHK. Our main findings are: first, there are different patterns in leverage effect on 'bad news' between two markets, as well as various magnitude of volatility persistence over time between the two markets. This may give supportive evidence to our findings in chapter 4 that the Chinese ADRs and the H shares have different return distributions.

Second, we find little evidence in support of MDH. The contemporaneous correlations are positive and statistically significant in only 3 of the 15 underlying shares on the SEHK. And all ADRs and remaining 12 underlying shares do not exhibit significant and positive correlation between volume and return volatility. Such weak evidence of contemporaneous correlations contradicts the prediction of the MDH.

Third, we find supportive evidence for the SIAH. The trading volume and return volatility are found to follow a clear lead–lag pattern in all ADRs and their underlying shares. But most of evidence suggests a Granger causality relation from trading volume to return volatility, though this is consistent with Darrat, Rahman, and Zhong (2003), we suspect the modified Baek and Brock test as developed by Hiemstra and Jones (1994) could make a deeper examination on the bidirectional relation between volume and volatility. However, due to the limit of time and difficult mathematical requirements, we have to leave it as future study.

Chapter 6

Conclusion

This thesis is to explore the issue of the arbitrage of the cross-listed securities by looking into a particular setting, the Chinese ADRs. This study is especially interested in investigating the securities trading behavior from the market microstructure perspective. The new things have been discovered as result of our research and added to the knowledge: 1. Differences in return distribution between the ADRs and their underlying shares can create arbitrage possibility; 2. Price differentials of the ADRs could be caused not only by contemporaneous but also lagged comovement effect; 3. Firms' ownership structure could be one of the factors to affect price differentials between the ADRs and their underlying shares; 4. Different liquidity risk and illiquidity cost are the factors determining the ADRs price differentials; 5. Differences in the investors' sentiment with bad news cause different volatility between the ADRs and their underlying shares.

First, we have demonstrated that for the cross-listed securities, differences in return distribution between the ADRs and their underlying shares may create arbitrage possibility. Earlier studies such as Kato et al. (1991), Miller and Morey (1996), and Karolyi and Stulz (1996) concluded that ADRs do not present investors with any arbitrage opportunities. These papers employed the approaches which only examine the locations, such as mean and median of the securities return data. However, we are particularly interested in return distributions because recently developed approach, for example, the Copula weighted portfolio which is based on the higher moment dependence between markets, has been widely used in international financial institutions to exploit arbitrage profit across multiple markets. Therefore, we adopted a set of methods to compare both location and shape of two securities return.

By employing the approach of Kato et al (1991), we compared the mean and median of the Chinese ADRs and their underlying H shares return, we could not reject the equality of two securities return as Kato et al reported in their paper. On the other hand, by employing the approach of Rabinovitch et al (2003) to compare return distribution, we found two securities return distributions are different for most of the Chinese ADRs. This finding reinforces the study of the ADRs arbitrage that difference in higher moments of securities return may create arbitrage possibility.

Second, we have demonstrated that price differentials between the Chinese ADRs and their underlying H shares are caused not only by contemporaneous but also lagged comovement effect, and the comovement effect with the US market dominates the effect with Hong Kong. We first used two correlation tests as Kato et al (1991) to examine pair-wise correlation between two securities' returns. Our finding of the correlation tests are similar to Kato et al (1991) that showed that the returns of the ADRs and the underlying stocks are significantly correlated, but these correlation coefficients are not close to one, and they suggested the non-overlapping trading hour is one of the possible reasons. We then followed the approach of Gagnon and Karolyi (2004) to specify the impacts of the US and Hong Kong market returns on each individual securities. Our findings are consistent with Gagnon and Karolyi (2004) who reported the significant contemporaneous comovement effect. At the same time, we contribute to the literature that we also revealed significant lagged comovement effect between market index and the ADRs' price differentials. Especially, with respect to the lagged comovement effect; we find negative and significant exposure to the US market index with one lag for all ADRs. This is because ADRs are clearly overreacting to innovations in the S&P 500 Index. This finding reinforces the study of Kim et al (2000), who reported that the ADRs response to the innovation of the S&P 500 is large, positive and highly significant at day 0, and followed by a large, significant negative price response on day 1.

Third, we have provided the evidence that apart from country specific factors such as local market impact, firm specific attributes such as firms' ownership structure would also affect the ADRs price differentials. Since part of the Chinese ADRs listed A shares in Shanghai after they listed H shares and ADRs, we are able to examine the impact of the difference in the ownership structure.

With respect with the return distributions and return spread, we showed an obvious structural break between the Chinese ADRs with A shares and those without A shares. We rejected the equality of return distribution for most of the ADRs with A shares, while rejected the equality of return distribution for only part of the ADRs without A shares. In terms of the descriptive statistics of return spread, we found for all the Chinese ADRs with A shares but only part of the ADRs without A shares, have negative skewness in their return spread. This means the ADRs with A shares tend to have lower return than their underlying H shares. This finding reinforces the 'Investors' Recognition Hypothesis' by Merton (1987), who argued that expected return of the firm’s stock decrease with the size of the investor’s shareholder base.

Further, with regard to the comovement effect, the ADRs with A shares and those without A shares are different in terms of the magnitude of the comovement effect. The Chinese ADRs without A shares are usually have larger correlation with the US and Hong Kong market indices, than those with A shares. This indicates that the ADRs without A shares tend to be more closely correlated with both market returns. Further, for the Chinese ADRs with A shares listed in Shanghai, we also considered the Shanghai market return, and found isolated market impacts from the domestic stock market on three ADRs.

Fourth, we have showed different liquidity risk and illiquidity cost are the factors determining the ADRs price differentials. Our investigation of the liquidity effect started from the comparison of the market microstructure and trading costs of the China’s domestic stock exchanges and Hong Kong stock exchange. We also compared the implicit trading costs of the three China-related stock exchanges with those of the US stock exchanges. The results clearly showed the NYSE and NASDAQ have the lowest implicit trading costs. Illiquidity reflects the impact of order flow on price, namely the discount that a seller concedes or the premium that a buyer pays when executing a market order, which results from adverse selection costs and inventory costs. Therefore, we employed a measure of the ratio of the daily absolute return to the dollar value of trading volume on that day as Amihud (2002) to measure daily illiquidity costs. On the other hand, Johnson (2007) demonstrated that the scale of liquidity innovations (liquidity risk) is positively related to volume, because intuitively, large changes in liquidity cannot occur without high trading volume, and a small amount of trading volume must imply a small change in liquidity. Therefore, we use trading volume as alternative measure of liquidity risk. Our findings demonstrated trading volume is a better proxy than illiquidity in explaining the ADRs price differentials. This finding also provided evidence to the theory of liquidity that the difference in the liquidity risk between the ADRs and their underlying shares can cause two securities have different prices.

Finally, we have given the proof that differences in the investors' sentiment with bad news cause different volatility between the ADRs and their underlying shares. We have examined the heteroscedasticity of return series and applied two General Autoregressive Conditional Heteroskedasticity (GARCH) models to measure return volatility. The two GARCH models we used in this thesis are known as asymmetric GARCH models to capture asymmetric characteristics of the positive/negative shock (namely good/bad news). We found that the Chinese ADRs and their H shares are clearly different in terms of the leverage effect on bad news. We showed that the leverage effect of 'bad news' for the ADRs is much bigger than that for the underlying H shares. This finding supports the 'Investor's Sentiment Hypothesis' proposed by De Long et al. (1990) and Shleifer and Vishny (1997), which argued stock's price are likely to be affected by investor's sentiment.

However, there also exist some limitations of this study. For example, we could make some improvements in liquidity proxy by using the moving variance of trading volume, which exactly measures the change of liquidity to measure liquidity risk. On the other hand, in spite of ILLIQ as reported being more likely a noisy measure, we also suspected that the statistically insignificant results of ILLIQ may be due to our use of daily data, which may increase the variance of ILLIQ data sets, and lower the significance level. Further, although we have provided evidence for SIAH when examining volume-volatility relation, we have only found significant Granger causality from volume to volatility. While the academic literature generally argues that volume causes price change and thus volatility, the street perception is volatility attracts volume. Some papers reported non-linear Granger causality existed either from volume to volatility or the converse by employing advanced methods; we are interested in a further study by applying alternative methods in future.

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