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Price transmission dynamics of Chinese ADRs listed on the New York Stock Exchange

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Abstract

Title: Price transmission dynamics of Chinese ADRs listed on the NYSE

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Key words: American Depositary Receipts, underlying shares, price transmission, Granger causality test, VECM, unit root, co-integration, impulse response, variance decomposition, NYSE, Hangseng, S&P 500

Purpose: This study aims to examine the price transmission among ADRs (American Depositary Receipts) and their underlying shares, US market index and Hong Kong market index. We will attempt to capture how a shock in the home market is transmitted to the foreign (and vice versa). In addition we will attempt to assess the relative weight of each variable in the system generating unexpected variations of its own and other variables and at what speed the shocks are absorbed.

Methodology: ADF unit root test, Johansen's co-integration test, Granger causality test, VECM, impulse response, variance decomposition

Empirical foundation: Five Chinese ADRs listed on the New York Stock Exchange. Each ADR represents a specific industry. Relevant Hong Kong and US market index. Sample period January 3, 2005 to October 31, 2006.

Conclusions: ADR prices are mostly influenced by its underlying share. There exists a long-run equilibrium co-integration relationship among the four variables in our system. Results indicate that Chinese ADRs are relatively independent from the behavior of the US market. At aggregate level, we find that there is a unidirectional information flow from US market to Hong Kong market with one day lag, but not vice versa. We find that the new information incorporated in the underlying shares price can be transmitted to the ADRs price within the same calendar day, whereas the lagged values of underlying shares price have little significantly impact on the current ADRs price. If there is a shock to one variable in the system, the shock will be transmitted and die away quickly.

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1. Introduction

The aim of this chapter is to introduce the reader to the research topic. The background provides the basic concepts for understanding the problem discussion that follows. Thereafter the purpose is stated. Finally an outline is presented covering the remaining parts of the thesis.

1.1 Background

In the 1980s investors in the United States (US) began more actively to place money overseas, with the desire to diversify their portfolios and to earn higher risk-adjusted yields than was possible in portfolios consisting of domestic shares only (Karolyi 1998).

For practical and legal reasons it may not be possible for all US investors to trade and own shares directly overseas. American depositary receipts (ADRs) represents a non-US firm's publicly traded equity. An ADR is essentially a share of a foreign firm and provides the investor with the same privileges and rights to dividends as an owner of ordinary shares in the home market (www.adrbny.com – Guide for investment).

A snapshot of trading activity in late 2006 reveals that the top listed ADRs by ownership value are companies such as British Petroleum, Nokia, Royal Dutch Shell. The first American Depositary Receipts was created by JP Morgan in 1927 for Americans to invest in British retailer Selfridge's (www.adr.com). Between 1997 and 2003 the share volume of exchange listed American Depositary Receipts increased annually at about 30 to 40 percent (www.adrbny.com – Guide for investment).

Today common stocks of many of the world's most prominent multinational firms are traded in ADRs form. There are over 300 ADRs listed on the New York Stock Exchange representing underlying shares from almost every industrialized country in the world (www.adrbny.com).

Economic globalization characterizes today's economic environment. The economic globalization can be attributed to two driving factors, first the need for worldwide industrial restructuring and secondly the availability of international capital. The process of global financial integration has over the last two decades provided potential welfare gains in terms of risk sharing benefits, higher investment activity, stock market development and overall growth (Wang & Yang 2004).

In the 1980s China initiated the process of changing its centrally planned economy to one increasingly based on market principles. The state ownership share in firms has ever since been reduced through capital ownership restructuring, and the share of private and foreign owners has increased. China's development can be explained by its accession to the World Trade Organization, accessing foreign markets, aligning with market oriented management and adopting "open-up" policies. China has developed a financial and banking system that enables Chinese firms to acquire capital from private and institutional investors abroad (Zhiguang 2006).

When Hong Kong was returned from the British in 1997 (Mitchell 2000, p. 16), China took over control of one of the world's most modern financial capitals. China is home to a number of firms that have gained access to the US equity market by listing part of their share equity on the New York Stock Exchange via Hong Kong.

The New York Stock Exchange (NYSE) is currently the largest equities marketplace in the world. The firms listed on the NYSE represented a total global market value of approximately 21 trillion USD, as of December 31, 2005. Non-US firms play an increasingly important role on the NYSE. There are roughly 450 non-US firms listed and their market value is approximately 7.1 trillion USD (www.nyse.com).

There are a number of commercial banks that run Depositary Receipt (DR) programs. The largest one is Bank of New York with a market share of 64 %. Other well known competing banks are JP Morgan Chase and Citibank (www.adrbny.com).

1.2 Problem discussion

There is a body of research relating to international capital market relationships and diversification. Grubel (1968) compares historical returns and standard deviations of US and international portfolios and finds benefits of international diversification.

The structure between international equity market indices during a world-wide financial crisis is investigated by Hillard (1979). The study examines closing prices of ten major stock exchanges around the time of the 1973 oil crisis. The study concludes that to the extent that they are related, most intra-continental prices move simultaneously, even in the context of hourly fluctuations. With respect to inter-continental prices, most do not seem to be closely related (with the exception of New York-Amsterdam). Later studies describe a different reality.

Eun and Shim (1989) attempts to answer three questions: (i) How much of movements in one market can be explained by innovations in other markets. (ii) Does the US market indeed influence other markets? Are there any markets whose movements are causally prior to those of other markets? (iii) How rapidly are price movements in one market transmitted to other markets? The study uses Vector Autoregressive (VAR) analysis and takes into consideration time zone differences between markets. This study provides support for substantial interdependencies among national stock markets in a global context.

According to the study the US market is the most important information producer affecting world stock markets. Asian and European markets respond with one day lag to innovations in the US market. Most responses to a shock are completed within two days suggesting that markets are efficient.

A more recent study by Bessler and Yang (2003) provides support for interdependencies among national stock markets and the leading role of the US market. The study indicates that international stock markets are neither fully integrated nor completely segmented, which suggests potential for international diversification. The Japanese market is found to be relatively isolated from other markets, which might suggest Japan to be a good candidate for the purpose of international diversification.

One of the first studies focusing on ADRs and their underlying shares within this area is made by Kim et al (2000). ADRs provide a unique opportunity to investigate price transmission channels. ADRs are traded in the US but represent a foreign firm's underlying share. Their study "Price Transmission Dynamics between ADRs and their Underlying Foreign Securities" investigates the relative importance of, and the speed of adjustment of ADR prices to three pricing factors: underlying share, US market index and relevant exchange rate. ADRs are quoted in dollars whereas the underlying security is quoted in its domestic currency. This means that movements in the foreign currency should be reflected in the ADR price. Also the US market may have an impact on the ADR for two reasons. Firstly investors may evaluate the systematic risk of ADRs with reference to the US index. Secondly many foreign markets are positively correlated with the US market. Many foreign markets are closed when the US market is open – so if returns of the following day are positively correlated then one may expect a positive contemporaneous relationship between ADR returns and US market index returns. The data in the study consists of daily closing prices for 21 Japanese, 21 British, 5 Dutch, 5 Swedish and 4 Australian firms for the period January 4 1988 to December 31 1991 (adjusted for dividends and splits). In addition the study uses daily spot rates against the dollar and daily closing prices of the S&P 500 index.

Most responses of the ADRs to the unexpected movements of the other markets occur on the same calendar day. Although the most influential factor in pricing ADRs is their underlying shares, the role of foreign currency value against the US dollar has been growing, especially in recent years. Shocks from the currency markets clearly persist beyond the same calendar day whereas those from the underlying share markets do not consistently extend beyond the same day. The influence of US market movements is also borne out, although this influence is smaller than those of the other factors, and shocks from the US market do not appear to persist beyond the same calendar day.

The study does not include Chinese ADRs. We believe that the Chinese market at that time was less developed with fewer ADRs listed than today. This offers a possible explanation to the rareness of studies explicitly examining Chinese ADRs. We therefore intend to replicate relevant parts of the study by Kim et al. We find additional justification to this study given the size of China's economy and its increasingly important role in the world economy.

1.3 Purpose

This study aims to examine the price transmission among ADRs (American Depositary Receipts) and their underlying shares, US market index and Hong Kong market index. We will attempt to capture how a shock in the home market is transmitted to the foreign (and vice versa). In addition we will attempt to assess the relative weight of each variable in the system generating unexpected variations of its own and other variables and at what speed the shocks are absorbed.

1.4 Outline

After this introductory chapter the thesis proceeds according to following structure:

Chapter 2 - Theory

In this section we provide a theoretical framework for the academic problem by presenting facts, theories and previous research. In the final part we present our hypothesis.

Chapter 3 – Data & Methodology

This part of the thesis is dedicated to describing the data and methodology. After the data has been presented we proceed to explain and motivate the econometrical tests and models necessary for the study.

Chapter 4 – Empirical results & Analysis

In this section we display the results from the econometrical tests and models employed. The results are discussed and analyzed in each sub-section.

Chapter 5 - Conclusions

In this chapter we will attempt to elaborate on the results and discuss their meaning in a wider context.

2. Theory

In this chapter we provide a theoretical framework for the academic problem by presenting facts, theories and previous research. In the final part we present our hypothesis.

2.1 American Depositary Receipts

Demand for ADRs is driven by increasing desire of US individual and institutional investors to diversify portfolios, reduce risk and invest globally in the most efficient manner. American Depositary Receipts are especially convenient since investors do not have to deal on a foreign equity market or in a foreign currency. ADRs are traded in US dollars. The system has been so successful that even investors with the capacity to invest directly outside the US prefer ADRs (www.adrbny.com – Guide for investment).

American Depositary Receipts are legal, US securities that trade freely on a major exchange or in the over the counter (OTC) market in US dollars, pay dividends or interest in dollars, and settle, clear, and transfer according to standard US practices. Many American individual and institutional investors trade ADRs due to their cost effectiveness, simplicity, convenience, liquidity, and lower operational risk as compared to the risk of purchasing and safekeeping ordinary shares outside the US (www.adrbny.com – Guide for investment).

Looking from the issuing firms point of view, listing ADRs can potentially stimulate investor interest, improve visibility of the firm, broaden the shareholder base and improve liquidity. ADRs can also be used to raise capital in equity offerings (www.adr.com).

Karoliyi (1998) examines why companies list shares abroad. The main findings of this article, relevant to our study, can be summarized as follows. The share price reacts favorably to cross-border listing in the first month after listing. Post-listing price performance up to one year is highly variable across companies depending on the home and listing market, its capitalization, capital-raising needs and other company-specific factors. Post-listing trading volume increases on average, and, for many issues, home market trading volume increases also. Liquidity of trading in shares improves overall, but depends on the increase in total trading volume, the listing location and the scope of foreign ownership restrictions in the home market.

There are different types of ADRs, the main characteristics are as follows:

There is a crucial distinction between sponsored and un-sponsored ADRs. Un-sponsored ADRs are issued by more than one depositary in response to demand. Un-sponsored ADRs are becoming obsolete due to hidden costs and unclear transaction costs associated with their trade. Sponsored ADRs are issued and administered by one depositary and the relationship with the foreign firm is regulated via an agreement (Webster 1998).

Furthermore sponsored ADRs can be divided into four different levels.

Level I ADRs offer the simplest way for a foreign firm to access the US market. The foreign company does not have to fully comply with US Generally Accepted Accounting Principles (GAAP) or full Securities and Exchange Commission (SEC) disclosure. The level I ADRs do not enable firm's to raise capital or to be listed on national exchanges.

Level II ADRs enable capital raising and listing on major US exchanges such as the NYSE. Level II ADRs offer better visibility and possibly also better liquidity. Reporting costs are higher and there is need for SEC compliance.

Level III ADRs not only have to comply fully with SEC requirements but also GAAP requirements (Webster 1998). In addition Level II and III ADRs can be listed on exchanges outside the US. Private placement (114A) Depositary Receipts are capital raising issues in which securities are privately placed to qualified institutional investors (QIBs). Private placement (114A) Depositary Receipts do not require SEC or GAAP compliance (www.adrbny.com – Guide for investment).

ADR trade can enter into following procedures: issuance, intra trade and cancellation.

Issuance is carried out by a local broker in the home market. The broker either already owns shares or buys shares from the market in the local currency. The shares are deposited in a custodian bank and after that the depositary can issue ADRs representing those shares.

Intra trade means that ADRs put into circulation on the US equity market trade freely as any other common equity. Intra-market trading accounts for approximately 95 percent of all Depositary Receipts trading in the market (www.adrbny.com – Guide for investment).

Cancellation of existing ADRs is carried out via the local broker upon request from the investor. The broker can either sell the ADR into the intra market or sell it into the home market. The custodian bank then releases the deposited shares into the home market.

Serious trading of ADRs starts when four to eight percent of a firm's equity is traded in ADR form. Brokers will seek to obtain the best price by comparing the ADR price in the home market and the equivalent dollar price of underlying share in local currency. Broker will buy or sell in the market that offers the most cost efficient execution. This is carried out by any of the three procedures described above (issue, transferal or cancellation). If there is no difference in price the home and foreign market is in equilibrium or parity. If there is a price difference between the ADR and the underlying share large enough to cover transaction costs, an arbitrage opportunity exists.

In many regions of the world, the ADR market is open while the home market for the ordinary share is closed. In this case, the opening price of the ADR is based on the same calendar day's closing price in the home market. Likewise, the closing price of the ADR will also impact the opening price of the ordinary share when the home market opens. When the home market is closed, the ADR price will fluctuate based on the normal forces of supply and demand and the flow of available information.

The basic formula for how an ADR is priced (www.adrbny.com – Guide for investment):

DEPOSITARY RECEIPT PRICE = THE ORDINARY SHARE CONVERTED TO DOLLARS AT THE PREVAILING EXCHANGE RATE, ADJUSTED FOR THE APPROPRIATE RATIO PLUS ANY TRANSACTION COSTS

Would the ADR take on a higher price in dollars relative to the underlying share, it is traded at a discount or premium. As soon as the spread is large enough, investors and brokers in the two markets will try to seize the opportunity of arbitrage until it no longer exists and the two assets trade in parity.

2.1.1 Chinese ADRs

Chinese ADRs have increased in numbers lately. As this is written there are seventy-four Chinese ADRs (www.adr.com). Eighteen are listed on the NYSE and the rest of the seventy-four are allocated as follows: Twenty-one are listed on the NASDAQ; twenty-five are traded over the counter (OTC). The remaining ten are categorized as 144A/REGS – these securities are privately placed to qualified institutional buyers. ***Table B*** in Appendix shows the eighteen Chinese ADRs listed on the NYSE. Three ADRs have to be omitted from this study due to insufficient trading data (New Oriental Education & Technology Group, Mindray Medical International Ltd and Suntech Power Holdings Co.Ltd). The remaining fifteen ADRs provide enough trading data for the sample period and are all sponsored level III ADRs. We sort these ADRs into following industry branches:

- Transport: U:ZNH, U:CEA and U:GSH
- IT: U:CHL, U:CHU and U:CHA
- Energy: U:HNP, U:YZC, U:PTR, U:SNP, U:ACH and U:SHI
- Manufacturing: U:CBA and U:SMI
- Finance: U:LFC

2.2 Market efficiency and liquidity

Researcher Fama (1970) outlined three levels of efficiency for stock markets. The study is based on three different investment approaches that are supposed to generate abnormal returns (Arnold 2005, p 691). (i) Weak level efficiency implies that share prices fully reflect all information contained in past price movements. Trading rules aimed to exploit correlated regularities in past price movements to generate abnormal profits are ruled out. In econometric terms this form can be modeled using the random walk with drift model. The current price equals to previous periods, plus the expected return of the share and a random error term. (ii) Semi level efficiency states that share prices fully, immediately and without bias reflect all relevant public information. There is no point in analyzing publicly available information after a news release. The market has already absorbed information such as dividend announcements, rights issues, technical breakthroughs etc into the price. (iii) Strong level efficiency focuses on insider trading where individuals operating or closely connected to a firm would not be able to earn abnormal profits (Webster 1998).

Liquidity is an important property and a necessary condition for a market to be efficient. Liquidity refers to the speed and ease with which an asset can be converted into cash. The greater the interest and the more investors who participate in the trade of a security, the more rapidly information will be disseminated and reflected in its price. Also the quality and quantity of publicly available information have great importance for how exogenous shocks (from the outside) are incorporated into the share price. Inaccurate or corrupted information may cause abnormal effect on the share price. The greater the market efficiency the quicker prices will converge back to steady state after an exogenous shock (Webster 1998). Liquidity of ADRs is equal to or greater than the liquidity of the ordinary shares in the home market, due to the fact that ADRs are freely exchangeable with the ordinary shares and can be issued or canceled upon investor demand (www.adrbny.com – Guide for investment).

2.3 Capital market integration and the law of one price

Financial integration expresses the links between financial markets. There are three forms of financial integration: total, indirect and direct. Financial integration can also vary in strength along a scale from perfect integration to disintegration or segmentation. Total financial integration encompasses direct and indirect integration. Perfect (total) integration means that expected real interest rates are the same on the markets in question. Where total financial integration is not perfect, this may be due to imperfect direct and/or indirect financial integration. Direct financial integration, which is also referred to as capital market integration, is expressed in deviations from "the law of one price" for financial securities. If two markets are perfectly financially integrated this law should hold and an investor could expect the same risk-adjusted return. If the differential in expected risk adjusted returns is greater than zero but less or the same as the transaction costs then the markets are disintegrated but still efficient (Oxelheim 1996, p. 113).

Alaganar and Bhar (2001) investigate characteristics of the Australian ADRs traded in the US. The study establishes that the 'law of one price' holds for ADRs. For a global investor, an ADR portfolio is a cost-effective means of obtaining superiority in the mean-variance context as measured by the reward to risk ratio. The study also finds that the ADR portfolio offers a low correlation with the US index under high external shock states, which is of interest to US investors seeking global diversification.

Suarez (2005) examines if arbitrage opportunities are a myth or reality using a high frequency data set of French and American stocks. Even if infrequent, this study shows that large deviations from the law of one price are present in the data and an arbitrage trading rule reveals that profits could have been made. The markets in this study were classified as disintegrated and not fully efficient.

2.4 Previous research

In chapter one, we presented the central piece of research for this thesis "Price Transmission Dynamics between ADRs and their Underlying Foreign Securities". There are a number of relating studies after 2000 which we will briefly review.

Choi and Kim (2000) empirically examine major determinants of ADRs and their underlying stock returns. The pricing factors considered are underlying stock returns, world market returns, country factors (local and US market returns), industry factors (world, local, and US industry factors), and relevant exchange rates. Except for the exchange rates, all the other determinants considered are important factors in explaining the behavior of ADRs and their underlying stock returns. The relative importance, however, depends on several factors such as the degree of industry globalization or market types (emerging or developed markets). The study finds evidence that ADRs help US domestic investors diversify internationally, especially through the emerging market ADRs. The results of this study have implications that ADR markets are segmented, and thus an asset pricing model with local and world factors will fit ADRs and their underlying stock returns.

Chen, Chou and Yang (2002) study the price transmission effect between ADRs or GDRs (Globally Depositary Receipts) and their respective underlying shares. Data coveres twenty one sponsored Depositary Receipts issued by Taiwan listing companies from October 8, 1997 to May 31, 2000. Long and short run causal relations between the returns of both capital markets are examined. Results reveal one-way causality from Taiwan's capital market to foreign markets. This asymmetry suggests the domestic market plays a dominant role relative to the foreign market. At the same time, the prices of both markets will make opposite adjustment to establish the long run co-integrated equilibrium.

Wang and Lin (2005) examine the asymmetric price transmission dynamics between Taiwanese. ADRs and their underlying securities traded either on the NYSE, AMEX, or NASDAQ. The sample period is from the issuing date to June 30, 2003. The study finds that ADRs are integrated with their underlying Taiwanese securities for all cases. This indicates that a long-run equilibrium constraint occurs between them, and that an opportunity for arbitrage may not exist.

Kutan and Zhou (2006) investigate factors affecting mean returns of Chinese ADRs listed at the NYSE and their conditional volatility. Results from both low- and high-volume ADRs portfolios indicate that underlying, local, and host markets all are important predictors of the Chinese ADRs returns. In terms of the conditional volatility, only underlying market has a significant impact on the volatility of the

ADRs. Negative correlation is found between the US market returns and those of the ADRs at NYSE. Also, US shocks have no significant impact on the conditional volatility (risk) of the ADRs. Results suggest that the ADRs offer significant diversification benefits to US investors.

2.5 Our hypothesis

According to the no-arbitrage condition and the law of one price, ADRs price should be influenced most by its underlying share price. For there to be a diversification gain from investing in ADRs, they should be reasonably independent from the US market. The majority of forecast error variances of ADRs returns are explained by innovations originated from its underlying shares rather than itself, and innovations in US market have comparatively less explanatory power for the forecast error variances of ADRs returns. In addition, because of the highly developed information technology nowadays, we believe that the markets are informationally efficient, which means that the new information incorporated in the underlying shares price can be transmitted to the ADRs price within the same calendar day, whereas the lagged values of underlying shares price have little significant impact on the current ADRs price. If there is a shock to one variable in the system, the shock should be transmitted and die away quickly. Furthermore, in aggregate level, according to the leading role of US market with respect to information discovery based on previous research, we believe that there is a unidirectional information flow from US market to Hong Kong market with one day lag, but not vice versa.

3. Data & Methodology

In this chapter data and methodology is described. After the data has been presented we proceed to explain and motivate the econometrical tests and models necessary for the study.

3.1 Data

As described in part 2.1.1 the number of ADRs are limited to fifteen. Instead of forming a portfolio of all the fifteen we instead study the five ADRs below individually by industry branch. In line with Kim and Choi (2000) who find relevance of industry factors, we believe valuable features could disappear if the ADRs are treated in portfolio form. The same research has been performed on remaining ten ADRs, their results are available upon request. Daily adjusted closing prices of the ADRs and their underlying shares are collected from *Datastream*.

- China Mobile Ltd (IT)
- PetroChina Co.Ltd (energy)
- China Eastern Airline Co. Ltd (transportation)
- Brilliance China Automotive Holdings Ltd (manufacturing)
- China Life Insurance (finance)

We have also collected daily time series data on the S&P 500 composite and the Hangseng price index. S&P 500 represents US host market and Hangseng represents the underlying Hong Kong market. Note that the underlying market of Chinese ADRs is Hong Kong Stock Exchange, instead of the local Shanghai Stock Exchange or Shenzhen Stock Exchange. The motivation for including the US and Hong Kong market index is as follows. According to Kutan & Zhou (2006), the underlying Hong Kong market has significant influence on the price behavior of Chinese ADRs listed on the NYSE. According to Kim et al (2000), US market conditions may also affect the price behavior of Chinese ADRs for two reasons. First, ADRs are traded in US market during North American trading hours while their underlying Hong Kong market is closed (http://www.timeanddate.com). If new information gets to the US market, the underlying Hong Kong market would respond in the next trading day, while we would expect a contemporaneous relationship between Chinese ADRs and the host US market. Second, investors may evaluate the systematic risk of ADRs with respect to US market index. Therefore, it is necessary to include the host US market S&P 500 composite index in our analysis. As for the exchange rate factor, since Hong Kong Dollar is pegged to US Dollar (1:7.8) through a currency board system, which requires both the stock and the flow of the monetary base to be fully backed by foreign reserves. Any change in the size of the monetary base has to be fully matched by a corresponding change in the foreign reserves. Because of the nature of the pegged currency board regime, the exchange rate should not significantly influence the price behavior of Chinese ADRs. Therefore the exchange rate factor is not considered in our analysis (Kutan & Zhou 2006).

In our article, the sample period is from January 3, 2005 to October 31, 2006. This sample period provides enough fresh observations, and does not stretch too far back in time. As in previous studies holidays on either market are excluded from the data sample. Our data consists of 442 observations for each ADRs. All prices are quoted in US Dollars.

Before moving on to the next stage, we look at the descriptive statistics of each price series data, which are shown in ***Table 3.1***. As we can see, all the price series are not normally distributed at 1% significance level. In our study, the Jarque-Bera test is just a tool for describing the data, not as a concern of violation of the normality assumption, which is virtually inconsequential for a sufficiently large sample size. The two market price index (S&P500 and Hangseng), and four ADRs (U:CHL, U:CEA, U:CBA and U:LFC) as well as their underlying stocks have positive skewness, which means their distribution has a long right tail. In contrast, the U:PTR as well as its underlying stocks has a long left tail. As for the kurtosis, the two market price index (S&P500 and Hangseng), and four ADRs (U:CHL, U:CEA, U:PTR and U:LFC) as well as their underlying stocks have kurtosis less than 3, which means their distribution is peaked (leptokurtic[1]) relative to the normal distribution. In contrast, U:CBA as well as its underlying stocks has a flat (platykurtic) distribution relative to the normal distribution. The results in ***Table 3.1*** show that the ADRs and their corresponding underlying shares tend to have similar distribution This is as expected because in a perfect no-arbitrage market they should be priced identically.

Table 3.1
Descriptive statistics of each price series

	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	p-value
U:CHL	24.03158	23.955	40.78	14.91	6.087137	0.523928	2.617694	22.91328	0.000011
U:CEA	16.43894	16.27	21.99	12.7	1.923509	0.457054	2.865331	15.72287	0.000385
U:CBA	16.49186	16.27	22.72	12.67	1.835983	0.528944	3.224704	21.5405	0.000021
U:PTR	87.02572	83.7	122.75	51.65	19.4694	-0.08183	1.734208	30.00094	0
U:LFC	42.96927	32.075	86.31	25.2	18.17604	0.838506	2.338997	59.84118	0
K:CHT	4.792695	4.7495	8.123	3.007	1.211908	0.514858	2.586609	22.67472	0.000012
K:CHEA	0.164321	0.162	0.219	0.126	0.018857	0.51488	2.966476	19.54983	0.000057
K:CBA	0.165468	0.1635	0.223	0.128	0.018379	0.495159	3.061872	18.13229	0.000116
K:PECH	0.870154	0.838	1.232	0.516	0.195768	-0.0806	1.747867	29.35287	0
K:CLS	1.073767	0.8	2.143	0.622	0.451755	0.837869	2.32611	60.07932	0
S&P500	1246.022	1243.26	1389.08	1137.5	52.32172	0.299932	2.498846	11.25245	0.003602
HANGSENG	1969.877	1958.305	2358.71	1712.39	165.4316	0.355532	2.182655	21.61499	0.00002

3.2 Unit root and co-integration test

In order to form a statistically adequate model, the variables should first be checked as to whether they can be considered stationary or non-stationary. In our analysis, a stationary series can be defined as one with a constant mean, constant variance and constant auto-covariance for each lag. We use Augmented Dicky-Fuller (ADF) method to determine if the data is stationary or not (Brooks 2004, chapter 7)

[1] More information Brooks 2004 page 179-180

The model is:

$$\Delta y_t = \psi y_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta y_{t-i} + \mu + \lambda t + u_t, \quad u_t \sim iid(0, \sigma^2)$$

where $\lambda = 0$ if there is no deterministic time trend, and $\mu = \lambda = 0$ if there is neither deterministic time trend nor drift, which is our case when performing the tests. The motivation of using "*Augmented*" *Dicky-Fuller* test method (including p lags of the dependent variable $\sum_{i=1}^{p} \alpha_i \Delta y_{t-i}$) is because the lags of Δy_t can "soak up" any dynamic structure present in the dependent variable, to ensure that u_t is not auto-correlated. The number of lags *p* of the dependent variable is chosen by minimizing the value of Schwarz's Bayesian Information Criterion (SBIC). The t-statistic is employed, and it takes the form: t-statistic = $\hat{\psi} / \hat{SE}(\hat{\psi})$. The null hypothesis $H_0 : \psi = 0$ is tested against $H_1 : \psi < 0$. If we reject the null hypothesis, then the series is stationary, it doesn't contain a unit root. If we fail to reject the null hypothesis, which means ψ is not significantly different from zero, then the series is non-stationary.

If, as expected, all the log price series are integrated of order I(1), then the next step would be to test for co-integration among the four variables in our system: ADRs log price, underlying stocks log price, S&P500 and Hangseng market log price index. In our context, the four variables are defined as co-integrated if at least one linear combination of them is stationary, i.e. $y_{1t} - \hat{\gamma}_1 - \hat{\gamma}_2 y_{2t} - \hat{\gamma}_3 y_{3t} - \hat{\gamma}_4 y_{4t} = \hat{u}_t$, where $\hat{u}_t$ is stationary if co-integrated. A co-integrating relationship may be seen as a long-term or equilibrium phenomenon, although the variables may deviate from their relationship in the short run. The law of one price suggests that the ADRs log price and its underlying stocks log price should be co-integrated since they are obviously prices for the same asset at different market location, and hence will be affected in very similar ways by given pieces of information. Since there are four variables in our system, i.e. g=4, there can be at most 3 linearly independent co-integrating vectors, i.e. $r \leq 3$. This motivates us to use Johansen's technique (Johansen 1988, 1991 and 1995a)[2] to perform the multivariate co-integration test because it will allow determination of multiple co-integrating relationship. The model is:

$$\underset{g*g}{y_t} = \underset{g*g}{\beta_1}\underset{g*1}{y_{t-1}} + \underset{g*g}{\beta_2}\underset{g*1}{y_{t-2}} + \cdots + \underset{g*g}{\beta_k}\underset{g*1}{y_{t-k}} + \underset{g*1}{u_t}$$

where g is the number of variables in our system, and k is the number of lags. We rewrite the model as follows:

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \cdots + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t$$

$$\text{where} \quad \Pi = (\sum_{i=1}^{k} \beta_i) - I_g \quad \text{and} \quad \Gamma_i = (\sum_{j=1}^{i} \beta_j) - I_g$$

The trace statistic is employed, and it is a joint test where the null hypothesis is that the number of co-integrating vectors is less than or equal to r against that there are more than r co-integrating relationships. The trace statistics takes the form:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i)$$

where r is the number of linearly independent co-integrating vectors and $\hat{\lambda}_i$ is the estimated value for the i^{th} ordered *eigen value* from the Π matrix (Johansen 1988, 1991 and 1995)[3].

3.3 Granger causality test based on Vector Error Correction Model

If there exists long-term equilibrium co-integrating relationship among the four variables in our system: ADRs log price, underlying stocks log price, S&P500 and Hangseng market log price index, it is necessary to use Vector Error Correction Model (VECM, henceforth) as the base of our further analysis in order to incorporate this long-term relationship. VECM is a restricted VAR (Vector Auto-regression, developed by Sims (1980)) model designed for use with non-stationary series that are known to

[3] See aslo Eviews Users Guide

be co-integrated. It can be expressed as:

$$\Delta y_{1t} = \alpha_{10} + \sum_{k=1}^{k} \beta_{1k} \Delta y_{1,t-k} + \sum_{k=1}^{k} \lambda_{1k} \Delta y_{2,t-k} + \cdots + \sum_{k=1}^{k} \theta_{1k} \Delta y_{g,t-k} + \delta_1 (y_{1,t-1} - \gamma_1 - \gamma_2 y_{2,t-1} - \cdots - \gamma_g y_{g,t-1}) + u_{1t}$$

$$\vdots$$

$$\Delta y_{gt} = \alpha_{g0} + \sum_{k=1}^{k} \beta_{gk} \Delta y_{1,t-k} + \sum_{k=1}^{k} \lambda_{gk} \Delta y_{2,t-k} + \cdots + \sum_{k=1}^{k} \theta_{gk} \Delta y_{g,t-k} + \delta_g (y_{1,t-1} - \gamma_1 - \gamma_2 y_{2,t-1} - \cdots - \gamma_g y_{g,t-1}) + u_{gt}$$

where g is the number of endogenous variables in the system (g=4 in our case), k is the number of lags, $(y_{1,t-1} - \gamma_1 - \gamma_2 y_{2,t-1} - \cdots - \gamma_g y_{g,t-1})$ is known as the error correction term since the deviation from long-term equilibrium is corrected gradually through a series of partial short-term adjustments. Broadly, δ_g measures the speed of adjustment of the g^{th} endogenous variable towards the equilibrium, and its strict definition is that it measures the proportion of last period's equilibrium error that is corrected for. Note that we use the sequential modified likelihood ratio (LR) test to determine the optimum lag length *k*. This method starts from the maximum lag, testing the null hypothesis that the coefficients on lag *l* are jointly zero using the χ^2 statistics. We then compare the modified LR statistics to the 5% critical values starting from the maximum lag, and decreasing the lag one at a time until we first get a rejection. The VECM model provides a multivariate framework where changes in a particular variable are related to changes in its own lags as well as lags of other variables, and furthermore taking the adjustments to the long-run equilibrium relationship into consideration. An advantage of VECM is that there is no need to specify which variables are endogenous or exogenous-all are endogenous in the system (Brooks 2004, chapter 6).

Furthermore, provided that there are no contemporaneous terms on the RHS[4] and all

[4] Right Hand Side

equations have identical regressors, it is valid to use OLS[5] and standard procedures for statistical inference even though the innovations u_{gt} may be contemporaneously correlated. All these reasons motivate us to use VECM as the appropriate model in our research.

Since the VECM above always include many lags of variables, it is troublesome and has little practical implication to examine the coefficient estimates individually. Therefore, evaluation of the significance of variables in the context of VECM usually occurs on the basis of joint tests on all of the lags of a particular variable. This motivates us to use this kind of test described by Granger (1969) and a slight variant due to Sims (1972). Granger causality test can not only determine which of the variables on the RHS of the model could have jointly statistically significant prediction on the future value of each variable on the LHS[6] of the model, but also point out the direction of information flow. Granger's approach to the question of whether y_2 causes y_1 is to see whether adding lagged values of y_2 can significantly improve the explanation of current y_1. y_2 is said to *Granger-cause* y_1 if y_2 helps in the prediction of y_1, or equivalently if the coefficients on lagged y_2's are jointly significantly different from zero in the equation for y_1, i.e. we reject the joint null hypothesis $H_0 : \lambda_{11} = \lambda_{12} = \cdots = \lambda_{1k} = 0$. The reported F-test-statistics is the Wald statistics (EViews 5 User's Guide, page 376) for the joint null hypothesis $H_0 : \lambda_{11} = \lambda_{12} = \cdots = \lambda_{1k} = 0$. If y_2 causes y_1 and y_1 causes y_2 at the same time, it would be said that there exists "bi-directional causality/feedback". If y_2 causes y_1 but not vice versa, it would be said that there exists unidirectional causality from y_2 to y_1, and variable y_2 is strongly exogenous in the equation for y_1. If neither y_2

[5] Ordinary Least Squares
[6] Left Hand Side

causes y_1 nor y_1 causes y_2, it would be said that y_1 and y_2 are independent of each other. Note that the statement "y_2 Granger causes y_1" does not imply that y_1 is the effect or the result of y_2, it only measures the correlation between the current value of y_1 and the past values of y_2.

3.4 Impulse responses and variance decompositions

The Granger causality test above can determine which set of the variables on the RHS of the model could have jointly statistically significant impacts on the future value of each variable on the LHS of the model, but it can not reveal whether changes in the value of a given variable would have a positive or negative impact on other variables in the system, or how long the impact would persist. Fortunately, however, such information can be revealed by analysis of impulse response and variance decomposition (Brooks 2004, chapter 6). Based on this motivation, we perform impulse response and variance decomposition analysis below.

Impulse responses can trace out the dynamic responsiveness of each dependent variable to one unit random shock or innovation in each particular variable in the system. A shock to the i^{th} variable not only directly affects the i^{th} variable but is also transmitted to all of the other endogenous variables through the dynamic (lag) structure of the model. Since the large number of coefficients containing complicated cross-equation feedbacks makes the estimated model difficult to interpret intuitively, as suggested by Sims (1980), it is better to transform the model into an infinite Vector Moving Average (VMA henceforth) by successive substituting on the RHS of the model, where each dependent variable is represented as a linear combination of current and past one-step-ahead forecast errors or innovations.

If the system is stationary, the impacts of the innovations or shocks should gradually die away. The *i,j*th component of coefficient matrix of VMA represents the *i*th variable's response to one unit random shock in the *j*th variable but none in other variables. However, the error terms or residuals may be contemporaneously correlated across equations even though they are serially uncorrelated by construction. This implies that one unit random shock in one variable may also work through the contemporaneous correlations with other variables. In fact, the error terms usually have a common component that cannot be attributed to a single variable alone. Therefore, in order to interpret the impulse response behavior unambiguously, we have to apply a transformation to the error terms so that they become both serially and contemporaneously uncorrelated. In this paper, as Yang et al (2003) suggested, we use generalized impulses transformation described by Pesaran and Shin (1998). The most appealing advantage of this approach is that the results are not dependent on the ordering of the variables.

On the other hand, variance decompositions can examine how much of the s-step-ahead (s=1,2,…) forecast error variance of a particular variable is explained by innovations to each explanatory variable. Thus, variance decompositions provide information about the relative importance of each random shock or innovation in generating the fluctuations of each dependent variable in the model. Note that when perform the transformation to the error terms, we need to use orthogonalised Cholesky factorization (Sims 1980), because non-orthogonal factorization will yield decompositions that do not necessarily add up to 100%. This approach attributes all of the effect of any common component to the variable that comes first in the model. Thus, the results are sensitive to the ordering of the variables, and the more highly contemporaneously correlated are the residuals, the more the variable ordering will be important (Lutkepohl 1992). In this paper, we specify the ordering of the variables as: S&P500, underlying shares, Hangseng and ADRs according to the relative degree of exogenity (ranked according to a priory expectation).

In addition, according to Runkle (1987), "reporting variance decompositions and impulse response functions without confidence intervals is equivalent to reporting regression coefficients without *t*-statistics”. Therefore, in this paper, Monte Carlo technique is implemented to specify standard errors around impulse response functions and variance decompositions for statistical inference (Soydemir Gokce 2000).

4. Empirical results & analysis

In this section we display the results from the econometrical tests and models employed. The results are discussed and analyzed in each sub-section.

4.1 Unit root and co-integration test

We use ADF method to perform the unit root test on both the log price series and their log return series $\log(p_t) - \log(p_{t-1})$. We report t-statistics and p-value for each test, which are shown in ***Table 4.1***.

Table 4.1
ADF unit root test results

	log price series		log return series	
	t-statistic	**p-value***	**t-statistic**	**p-value***
U:CHL	2.878779	0.9991	-23.67873	0
U:CEA	-1.082303	0.2528	-19.36551	0
U:CBA	-0.674653	0.4245	-20.18953	0
U:PTR	1.321237	0.9532	-22.31683	0
U:LFC	2.843558	0.999	-21.67629	0
K:CHT	2.859782	0.9991	-20.66659	0
K:CHEA	-0.966112	0.2984	-20.7852	0
K:CBA	-0.699815	0.4134	-19.71142	0
K:PECH	1.384373	0.9586	-19.52802	0
K:CLS	3.043474	0.9995	-20.2211	0
S&P500	0.982034	0.914	-22.49333	0
HANGSENG	1.524349	0.9689	-20.31225	0

**MacKinnon (1996) one-sided p-values*

As one might anticipate, all the log price series fail to reject the null hypothesis that it contains a unit root while the log return series are all stationary at 1% significance level, suggesting all the log price series are integrated of order I(1). This result is consistent with the efficient market hypothesis together with rational expectations, which suggest that asset prices should follow a random walk process. However, note that the transportation industry firm U:CEA and the manufacturing industry firm

U:CBA seem to follow a less perfect random walk process since their p-values are much smaller than firms in the other three industries. Also consistent with previous studies, S&P 500 and Hangseng market log price index series are also integrated of order I(1). According to Brooks, it is better to also perform stationarity test to confirm the unit root test's results. So we also perform the KPSS stationarity test (Kwiatkowski et al (1992)). The results of both the two tests are quite similar, so we can confirm that all the log price series are integrated of order I(1).

Since all the log price series, as expected, are integrated of order I(1), we perform Johansen's multivariate co-integration test to see whether there exists long-term equilibrium relationship among the four variables in our system: ADRs log price, underlying stocks log price, S&P500 and Hangseng market log price index. The results are shown in ***Table 4.2***.

As we can see, for all the five ADRs estimated, the null hypothesis of no co-integration relationship can be rejected but we fail to reject the null hypothesis of at most 1 co-integration relationship at 5% significance level, suggesting there exists one long-term equilibrium relationship. The results for the 5 firms in different industries are quite similar.

The long-run convergence evidenced by co-integration suggests that if price movement of ADRs and its underlying stocks diverges, market forces will act to eliminate the gap. Therefore, in the long run, the law of one price holds, the ADRs and its underlying stocks would effectively be substitute, and the diversification benefit is less obvious when investing in both markets.

Table 4.2

Johansen multivariate co-integration test results

	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.*
U:CHL	None	0.17954	106.432	47.85613	0
	At most 1	0.027644	19.95417	29.79707	0.426
	At most 2	0.017102	7.703833	15.49471	0.4976
	At most 3	0.000379	0.165778	3.841466	0.6839
	Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
U:CEA	None	0.10595	68.86873	47.85613	0.0002
	At most 1	0.029816	19.92739	29.79707	0.4278
	At most 2	0.014884	6.699382	15.49471	0.6128
	At most 3	3.35E-04	0.146226	3.841466	0.7022
	Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
U:CBA	None	0.105651	70.30585	47.85613	0.0001
	At most 1	0.028231	21.51075	29.79707	0.3265
	At most 2	0.020374	8.996145	15.49471	0.3657
	At most 3	1.58E-06	0.00069	3.841466	0.9803
	Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
U:PTR	None	0.158628	99.4017	47.85613	0
	At most 1	0.037677	23.92252	29.79707	0.2037
	At most 2	0.015862	7.139609	15.49471	0.5615
	At most 3	3.49E-04	0.152572	3.841466	0.6961
	Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
U:LFC	None	0.135036	86.58523	47.85613	0
	At most 1	0.026629	23.19073	29.79707	0.2368
	At most 2	0.024023	11.39625	15.49471	0.1883
	At most 3	0.001761	0.770136	3.841466	0.3802
	Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				

**MacKinnon-Haug-Michelis (1999) p-values*

4.2 Granger Causality test based on Vector Error Correction Model

The estimation results of VECM are presented in Appendix ***Table A***. Note that the coefficient δ of the error correction term in the equation for S&P500 index is insignificant in all the five cases, suggesting the leading role of the US market with respect to the information discovery.

Based on the VECM described above, we perform Granger causality test to report the direction and significance of the correlation between the variables in our system. The test results are shown in ***Table 4.3***. The reported F-test-statistics are the Wald statistics for the joint null hypothesis $H_0 : \lambda_{11} = \lambda_{12} = \cdots = \lambda_{1k} = 0$.

Table 4.3
Granger causality test results

ADRs	Null hypothesis	F-statistics	P-value	Null hypothesis	F-statistics	P-value
U:CHL	HANGSENG does not cause ADR	9.114574	0.1046	ADR does not cause HANGSENG	14.17571	0.0145
	S&P500 does not cause ADR	16.05721	0.0067	ADR does not cause S&P500	7.648299	0.1767
	UNDERLYING does not cause ADR	9.4507	0.0924	ADR does not cause UNDERLYING	9.925068	0.0774
	S&P500 does not cause HANGSENG	39.7179	0	HANGSENG does not cause S&P500	8.597916	0.1262
	UNDERLYING does not cause HANGSENG	7.033345	0.2182	HANGSENG does not cause UNDERLYING	4.091178	0.5364
	UNDERLYING does not cause S&P500	1.842057	0.8705	S&P500 does not cause UNDERLYING	15.34472	0.009
	HANGSENG,S&P500,UNDERLYING jointly do not cause ADR	28.61466	0.018	S&P500,UNDERLYING,ADR jointly do not cause HANGSENG	60.80589	0
	HANGSENG,UNDERLYING,ADR jointly do not cause S&P500	23.85472	0.0676	HANGSENG,S&P500,ADR jointly do not cause UNDERLYING	27.60271	0.0242
U:CEA	HANGSENG does not cause ADR	0.630098	0.7298	ADR does not cause HANGSENG	7.201439	0.0273
	S&P500 does not cause ADR	1.259693	0.5327	ADR does not cause S&P500	0.304534	0.8588
	UNDERLYING does not cause ADR	1.167497	0.5578	ADR does not cause UNDERLYING	12.66601	0.0018
	S&P500 does not cause HANGSENG	92.07012	0	HANGSENG does not cause S&P500	3.31967	0.1902
	UNDERLYING does not cause HANGSENG	0.91872	0.6317	HANGSENG does not cause UNDERLYING	0.424758	0.8087
	UNDERLYING does not cause S&P500	0.503184	0.7776	S&P500 does not cause UNDERLYING	1.336478	0.5126
	HANGSENG,S&P500,UNDERLYING jointly do not cause ADR	3.078944	0.7989	S&P500,UNDERLYING,ADR jointly do not cause HANGSENG	124.8964	0
	HANGSENG,UNDERLYING,ADR jointly do not cause S&P500	4.163134	0.6546	HANGSENG,S&P500,ADR jointly do not cause UNDERLYING	16.80337	0.01
U:CBA	HANGSENG does not cause ADR	2.785076	0.7331	ADR does not cause HANGSENG	3.719283	0.5905
	S&P500 does not cause ADR	7.942259	0.1594	ADR does not cause S&P500	14.91572	0.0107
	UNDERLYING does not cause ADR	1.362091	0.9284	ADR does not cause UNDERLYING	9.92871	0.0773
	S&P500 does not cause HANGSENG	95.05049	0	HANGSENG does not cause S&P500	10.18975	0.07
	UNDERLYING does not cause HANGSENG	4.193408	0.5219	HANGSENG does not cause UNDERLYING	4.58275	0.4689
	UNDERLYING does not cause S&P500	8.803351	0.1172	S&P500 does not cause UNDERLYING	5.843866	0.3217
	HANGSENG,S&P500,UNDERLYING jointly do not cause ADR	11.55772	0.7122	S&P500,UNDERLYING,ADR jointly do not cause HANGSENG	103.5322	0
	HANGSENG,UNDERLYING,ADR jointly do not cause S&P500	33.88363	0.0035	HANGSENG,S&P500,ADR jointly do not cause UNDERLYING	21.91904	0.1099
U:PTR	HANGSENG does not cause ADR	8.638376	0.1244	ADR does not cause HANGSENG	8.886618	0.1137
	S&P500 does not cause ADR	2.435504	0.7862	ADR does not cause S&P500	2.806903	0.7297
	UNDERLYING does not cause ADR	5.806458	0.3255	ADR does not cause UNDERLYING	5.10597	0.4031

	S&P500 does not cause HANGSENG	45.96103	0	HANGSENG does not cause S&P500	8.517335	0.1299
	UNDERLYING does not cause HANGSENG	10.60247	0.0599	HANGSENG does not cause UNDERLYING	5.784277	0.3278
	UNDERLYING does not cause S&P500	3.796009	0.5791	S&P500 does not cause UNDERLYING	4.303956	0.5065
	HANGSENG,S&P500,UNDERLYING jointly do not cause ADR	18.31193	0.2466	S&P500,UNDERLYING,ADR jointly do not cause HANGSENG	61.70742	0
	HANGSENG,UNDERLYING,ADR jointly do not cause S&P500	17.80989	0.2728	HANGSENG,S&P500,ADR jointly do not cause UNDERLYING	14.57985	0.4821
U:LFC	HANGSENG does not cause ADR	7.320804	0.1979	ADR does not cause HANGSENG	17.16038	0.0042
	S&P500 does not cause ADR	7.106564	0.2128	ADR does not cause S&P500	9.310456	0.0973
	UNDERLYING does not cause ADR	4.7335	0.4493	ADR does not cause UNDERLYING	3.140608	0.6783
	S&P500 does not cause HANGSENG	40.55148	0	HANGSENG does not cause S&P500	6.836927	0.2331
	UNDERLYING does not cause HANGSENG	6.854618	0.2317	HANGSENG does not cause UNDERLYING	5.324498	0.3776
	UNDERLYING does not cause S&P500	3.75353	0.5854	S&P500 does not cause UNDERLYING	7.976296	0.1575
	HANGSENG,S&P500,UNDERLYING jointly do not cause ADR	24.00641	0.065	S&P500,UNDERLYING,ADR jointly do not cause HANGSENG	68.08375	0
	HANGSENG,UNDERLYING,ADR jointly do not cause S&P500	23.49854	0.0741	HANGSENG,S&P500,ADR jointly do not cause UNDERLYING	18.75706	0.225

Consistent with previous studies, there is a distinct “larger market Granger causes smaller market” pattern. In all the 5 cases, US market Granger causes Hong Kong market at 5% significance level but not vice versa, so there exists a unidirectional causality relationship from US market to Hong Kong market. In aggregate level, information flows from US market to Hong Kong market but not backwards. Furthermore, at 5% significance level, we also find that Hangseng market index, ADRs and its underlying shares price jointly cannot Granger cause S&P500 market index, which means S&P500 market index is significantly exogenous in our system, and the US market can be viewed as dominant in terms of information discovery.

Next, we examine the Granger causality relationship between US market index and ADRs price. For the four ADRs (U:CEA, U:CBA, U:PTR, U:LFC), there is no Granger causality relationship between S&P500 and ADRs price at 5% significance level, suggesting they are independent of each other, which means lagged value of S&P500 market index can not help in prediction of the current value of ADRs price, and vice versa. For the firm U:CHL in IT industry, there exists a unidirectional causality relationship from S&P500 market index to ADRs price.

This may be explained by the fact that high-tech firms are more sensitive to the information in the US stock market than firms in other industries.

Finally, we examine the causality relationship between ADRs price and its underlying shares price. Surprisingly, except for U:CEA (unidirectional Granger causality relationship from ADRs to underlying shares), all the other 4 firms show no Granger causality relationship between ADRs price and its underlying shares price, which is inconsistent with the theories and some previous studies. One possible explanation for the ADR's independency is due to the different operating time of Hong Kong market and US market. Since Hong Kong market closes before US market opens within the same calendar day, if the markets are efficient, the information incorporated in the underlying shares price should be transmitted to the ADR´s price within the same calendar day. However, Granger causality test only can measure the correlation between the current ADRs price and the lagged underlying shares price, so it is necessary to further investigate the contemporaneous correlation between the variables.

4.3 Contemporaneous Residual Correlation Matrix

Based on the motivation above, as supplement to the Granger causality test, we present the contemporaneous residual correlation matrix to further investigate the contemporaneous relationship between the variables in our system. The residuals, or innovations, represent current abnormal price changes that were not predicted on the basis of all the information incorporated in the past prices. The contemporaneous residual correlations reflect the degree to which new information producing an abnormal price change in one variable is shared by other variables within the same calendar day. The results of the contemporaneous residual correlation matrix are presented in ***Table 4.4***.

Table 4.4
Contemporaneous residual correlation matrix

U:CHL	ADR	HANGSENG	S&P500	UNDERLYING
ADR	1	0.758422	0.45431	0.850524
HANGSENG	0.758422	1	0.152027	0.882062
S&P500	0.45431	0.152027	1	0.097019
UNDERLYING	0.850524	0.882062	0.097019	1
U:CEA	ADR	HANGSENG	S&P500	UNDERLYING
ADR	1	0.102703	0.276603	0.757511
HANGSENG	0.102703	1	0.151214	0.136164
S&P500	0.276603	0.151214	1	0.088705
UNDERLYING	0.757511	0.136164	0.088705	1
U:CBA	ADR	HANGSENG	S&P500	UNDERLYING
ADR	1	0.232348	0.254144	0.861167
HANGSENG	0.232348	1	0.14807	0.26099
S&P500	0.254144	0.14807	1	0.052216
UNDERLYING	0.861167	0.26099	0.052216	1
U:PTR	ADR	HANGSENG	S&P500	UNDERLYING
ADR	1	0.402089	0.425544	0.722384
HANGSENG	0.402089	1	0.153629	0.458467
S&P500	0.425544	0.153629	1	0.076866
UNDERLYING	0.722384	0.458467	0.076866	1
U:LFC	ADR	HANGSENG	S&P500	UNDERLYING
ADR	1	0.46308	0.342522	0.851612
HANGSENG	0.46308	1	0.116301	0.51314
S&P500	0.342522	0.116301	1	0.020248
UNDERLYING	0.851612	0.51314	0.020248	1

The results are as expected, in all the five cases, there exists a highly correlated contemporaneous relationship between ADRs price and its underlying shares price. Combined with the Granger causality test results in the above section, we can draw the conclusion that the markets are highly efficient and the new information incorporated in the underlying shares price can be transmitted to the ADRs price within the same calendar day, whereas the lagged values of underlying shares price have little significantly impact on the current ADRs price. From this viewpoint, ADRs price adjusts to the underlying shares price so quickly that it is very difficult to earn arbitrage benefit and the law of one price holds.

On the other hand, there exists a relatively low contemporaneous relationship between ADRs price and US market price index. Together with results of the Granger causality test that there does not exit any significant lagged relationship neither between these two variables, we can conclude that Chinese ADRs price behavior is relatively independent of US market. Investing in Chinese ADRs may therefore provide US investors a significant diversification benefit.

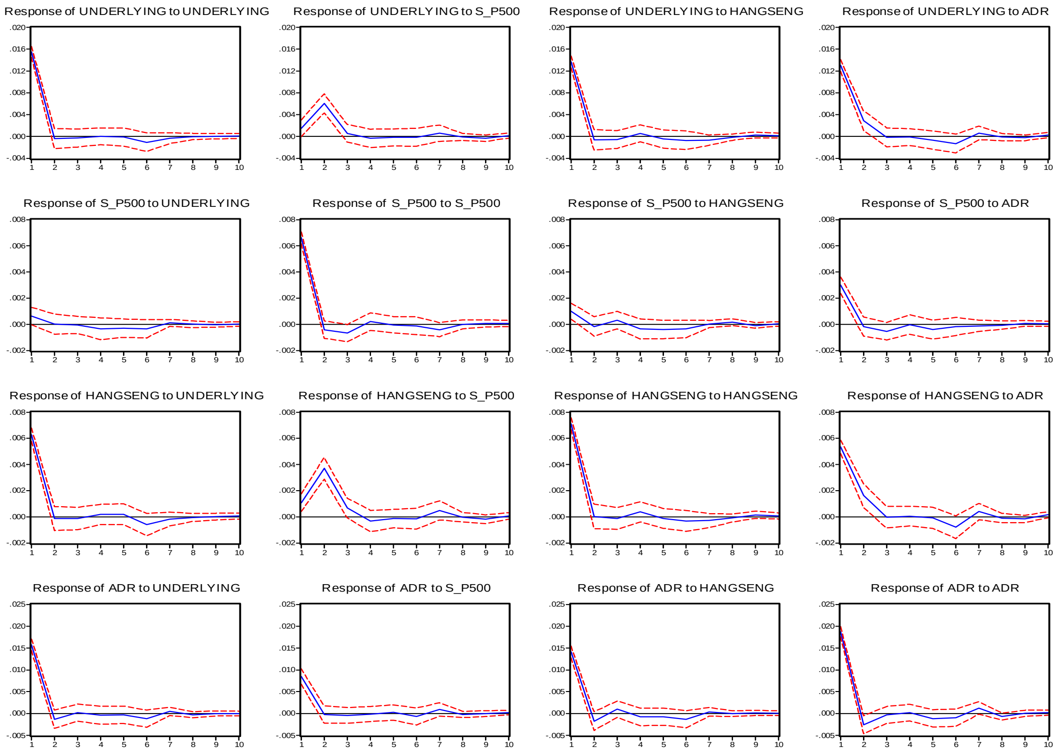
Furthermore, in aggregate level, we find that there exists a quite low contemporaneous relationship between Hangseng and S&P500 market index, which means the information in Hong Kong market cannot be transmitted to US market even within the same calendar day. This finding confirms the dominant role of US market with respect to information discovery.

4.4 Impulse responses and variance decompositions

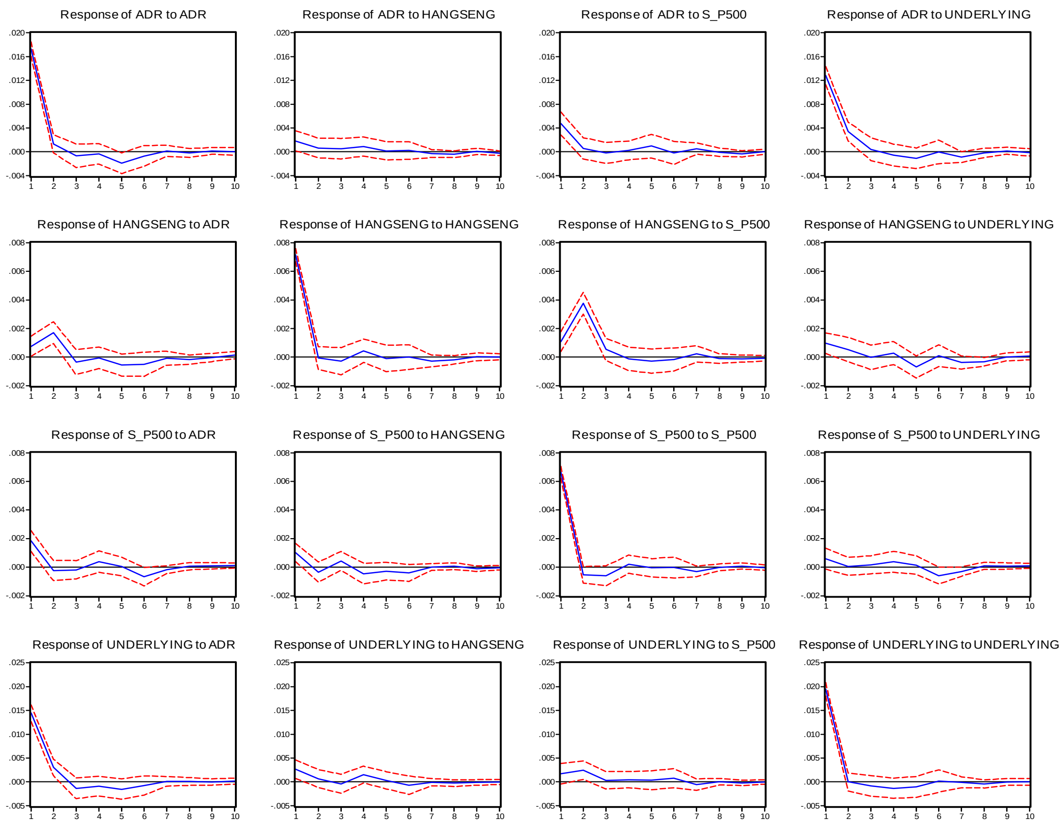
In order to investigate the magnitude and persistence of a typical shock, i.e., positive residuals of one standard deviation unit, in one variable to itself as well as to the other variables in the system, we present the results of generalized impulse responses in *Figure 4.1*. It tells us how fast information transmits from one variable to other variables. The vertical scale represents the magnitude of transmitted responses from a shock, while the horizontal scale represents the trading days (US market opens after Hong Kong market has closed). The dashed lines in the graph show Monte Carlo significance bands.

Figure 4.1
Generalized impulse responses

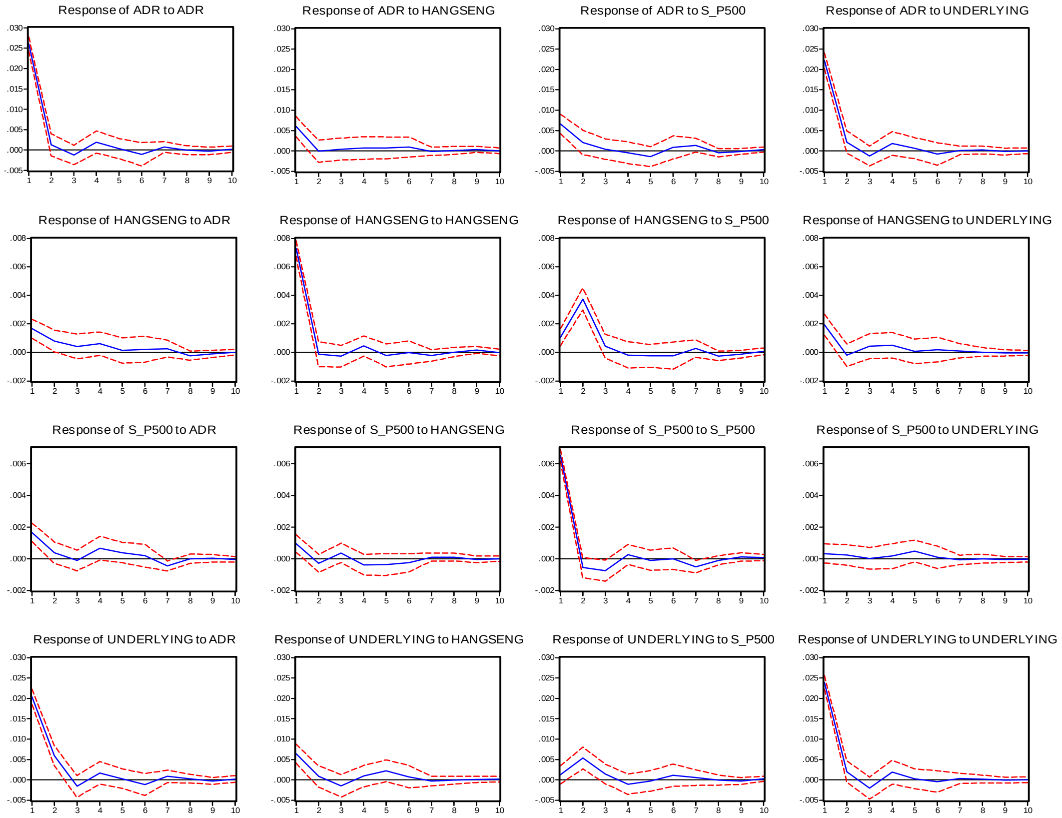
For U:CHL: Response to Generalized One S.D. Innovations ± 2 S.E.



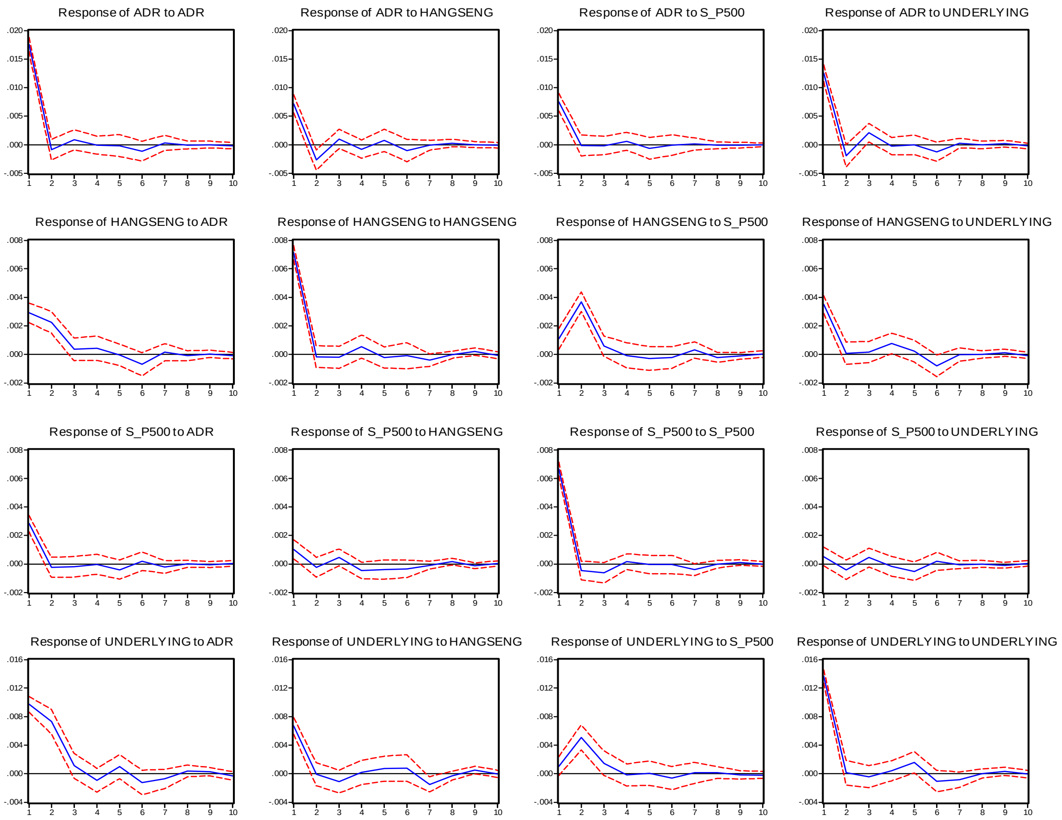
For U:CEA: Response to Generalized One S.D. Innovations ± 2 S.E.

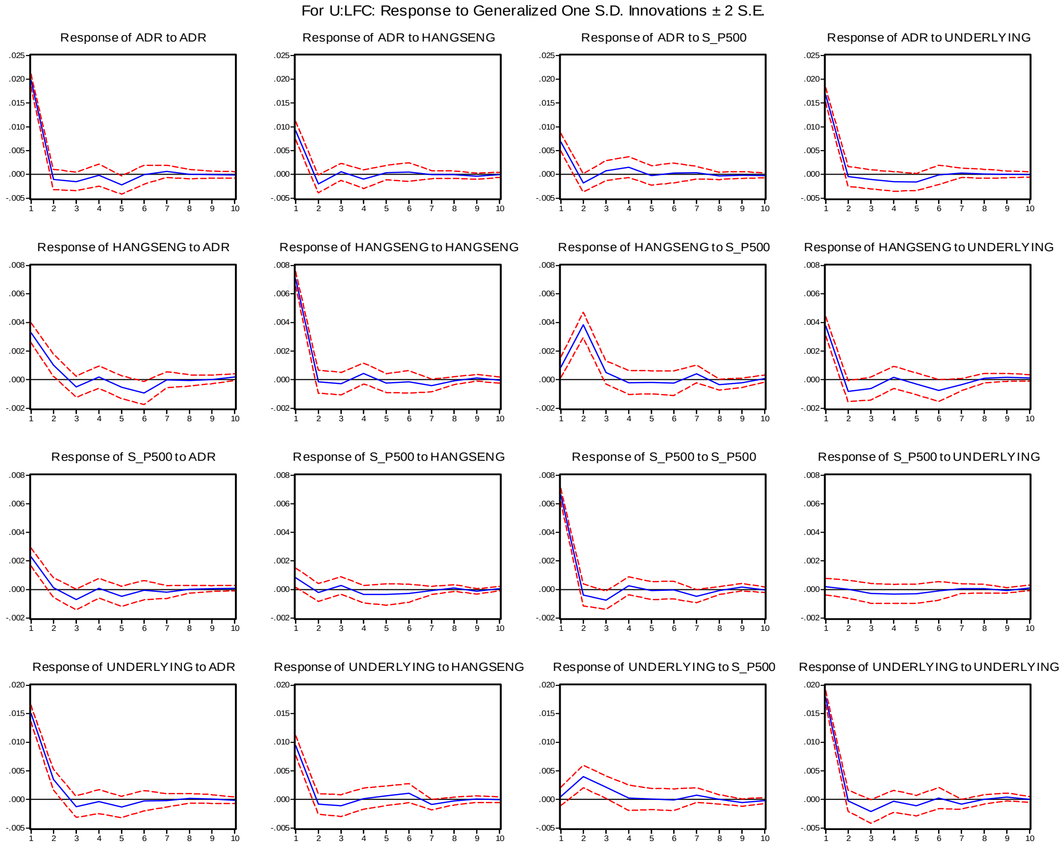


For U:CBA: Response to Generalized One S.D. Innovations ± 2 S.E.



For U:PTR: Response to Generalized One S.D. Innovations ± 2 S.E.





As can be seen from *Figure 4.1*, once again, the results of the five representative ADRs are very similar. A shock from the underlying shares has a positive and relatively large impact on the ADRs returns on day 1, and thereafter, the disturbance rapidly die away and become almost stabilized on day 3. A shock from US market transmits to the ADRs return through a quite similar dynamics, except that the magnitude of impact on day 1 is smaller. This confirms that the underlying shares have a greater explanatory power for ADRs return rather than the US host market.

On the other hand, US market has no distinct response to the shock in Hong Kong market, while Hong Kong market shows a visible and positive response on day 2 to the shock originated from US market. (Hong Kong market is already closed before US market opens, so it cannot respond until the next day (on day 2). This again confirms the dominant role of US market regarding to information discovery, i.e., in aggregate level information flows in a unidirectional manner from US market to the Hong Kong market.

In addition, the fact that shock impacts die away quickly and almost all the adjustments to the shocks are completed within two days is consistent with the notion of an informationally efficient market. This does not surprise us due to the highly developed information technology in the modern world.

Furthermore, in order to investigate how much of the forecast error variance of a particular variable is explained by innovations to each explanatory variable, we present results of the variance decompositions of the forecast errors in ***Table 4.5***. Each number in the table denotes the percentage of 2, 5, 10-day-ahead average forecast error variance of each variable explained by innovations in the variables on the top, respectively.

Table 4.5
Variance decompositions of forecast errors

For U:CHL

Variance Decomposition of S&P500:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.01920	0.02721	0.21819	0.00582	99.74878
		(0.33025)	(0.64744)	(0.31351)	(0.79554)
5.00000	0.01958	1.42826	2.11371	0.46645	95.99158
		(1.23661)	(1.76859)	(0.85267)	(2.05414)
10.00000	0.01975	1.91415	2.36304	0.76144	94.96138
		(1.44340)	(1.77573)	(1.09323)	(2.47659)

Variance Decomposition of UNDERLYING:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00808	1.77623	0.74226	83.81399	13.66751
		(1.05556)	(0.87604)	(2.78242)	(2.88175)
5.00000	0.00819	2.50815	1.61202	82.29722	13.58261
		(1.36899)	(1.14988)	(2.79960)	(2.84806)
10.00000	0.00834	3.68966	2.10785	80.77266	13.42983
		(1.61309)	(1.25821)	(2.92596)	(2.73855)

Variance Decomposition of HANGSENG:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00662	1.07187	16.93017	59.15661	22.84135
		(0.85189)	(1.58310)	(3.43270)	(3.46966)
5.00000	0.00679	1.72010	17.44640	57.75754	23.07596
		(1.07435)	(1.75357)	(3.40792)	(3.38422)
10.00000	0.00684	3.52232	17.50524	56.28495	22.68749
		(1.54628)	(1.82157)	(3.31072)	(3.29243)

Variance Decomposition of ADR:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.01686	18.55149	0.50965	61.33218	19.60668
		(2.45114)	(0.68139)	(3.59969)	(3.34737)
5.00000	0.01702	20.23430	1.80287	59.04538	18.91744
		(2.85041)	(1.36569)	(3.55670)	(3.39580)
10.00000	0.01723	20.69271	1.95434	58.40349	18.94946
		(2.96092)	(1.36060)	(3.48420)	(3.34889)

For U:CEA

Variance Decomposition of S&P500:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.01771	0.14141	0.18778	0.01639	99.65442
		(0.50000)	(0.38541)	(0.37442)	(0.71944)
5.00000	0.01801	0.32052	1.58424	0.43042	97.66482
		(0.78129)	(1.38811)	(0.66088)	(1.59689)
10.00000	0.01812	0.68661	1.85431	1.42372	96.03537
		(1.15290)	(1.36644)	(0.88148)	(1.97916)

Variance Decomposition of UNDERLYING:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00815	3.99084	0.02660	93.73792	2.24464
		(1.81350)	(0.27458)	(2.06367)	(1.29641)
5.00000	0.00827	4.70191	0.77223	92.23869	2.28718
		(1.91658)	(1.00591)	(2.35357)	(1.30369)
10.00000	0.00835	5.47497	0.95646	91.06990	2.49867
		(2.02986)	(1.11552)	(2.66791)	(1.40941)

Variance Decomposition of HANGSENG:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.01999	1.03158	74.66140	1.21051	23.09650
		(0.88193)	(3.76431)	(0.94019)	(3.68666)
5.00000	0.02025	1.93833	73.06837	1.97475	23.01855
		(1.25502)	(3.76981)	(1.36069)	(3.57523)
10.00000	0.02039	3.05658	71.84117	2.35038	22.75187
		(1.56935)	(3.85546)	(1.43439)	(3.45184)

Variance Decomposition of ADR:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00668	39.60342	0.06489	53.00049	7.33121
		(2.68199)	(0.36068)	(3.10140)	(2.22940)
5.00000	0.00678	40.30627	0.43015	51.85707	7.40650
		(2.62288)	(0.78318)	(3.07487)	(2.18305)
10.00000	0.00684	40.51234	0.53192	51.50798	7.44776
		(2.60630)	(0.85031)	(3.00963)	(2.22128)

For U:CBA

Variance Decomposition of S&P500:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.02629	0.86751	0.19890	0.16086	98.77273
		(0.99575)	(0.66758)	(0.48870)	(1.26997)
5.00000	0.02650	2.83391	1.74833	0.74076	94.67701
		(1.48735)	(1.50517)	(0.99417)	(2.46399)
10.00000	0.02663	3.66196	2.01975	0.75433	93.56397
		(1.70787)	(1.42251)	(0.99842)	(2.64636)

Variance Decomposition of UNDERLYING:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00822	6.32160	0.02879	89.00244	4.64717
		(2.45415)	(0.28133)	(2.97945)	(1.97298)
5.00000	0.00831	6.29842	1.07997	87.61313	5.00849
		(2.38877)	(1.19356)	(3.08243)	(2.09548)
10.00000	0.00835	7.02173	1.19225	86.60464	5.18137
		(2.48528)	(1.23674)	(3.09118)	(2.14061)

Variance Decomposition of HANGSENG:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.02540	0.13776	72.05802	5.49722	22.30701
		(0.30486)	(3.55102)	(1.95248)	(3.35875)
5.00000	0.02578	0.60745	71.12864	6.00788	22.25603
		(0.87063)	(3.54533)	(2.14794)	(3.36328)
10.00000	0.02594	1.00173	70.62979	6.02455	22.34393
		(1.05726)	(3.55057)	(2.16148)	(3.36080)

Variance Decomposition of ADR:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00659	23.22284	0.20897	69.62570	6.94250
		(2.06198)	(0.49460)	(2.65649)	(2.15201)
5.00000	0.00678	23.09581	0.37739	69.33914	7.18765
		(2.15485)	(0.82049)	(2.75395)	(2.22972)
10.00000	0.00684	23.14715	0.57288	68.76301	7.51697
		(2.20283)	(0.93008)	(2.79348)	(2.29894)

For U:PTR

Variance Decomposition of S&P500:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.01783	0.27998	0.00067	0.30362	99.41573
		(0.55531)	(0.28914)	(0.59899)	(0.85708)
5.00000	0.01804	0.76887	0.79043	1.48035	96.96035
		(0.85873)	(0.94705)	(1.17649)	(1.60564)
10.00000	0.01811	0.81969	1.41655	1.56600	96.19776
		(0.94555)	(1.19506)	(1.30825)	(1.81497)

Variance Decomposition of UNDERLYING:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00818	27.47910	0.23979	63.12951	9.15161
		(3.36966)	(0.54202)	(3.34617)	(2.58761)
5.00000	0.00827	28.28325	0.75122	61.49323	9.47230
		(3.25091)	(0.98898)	(3.36968)	(2.69048)
10.00000	0.00835	27.83938	2.15892	60.59689	9.40481
		(3.09887)	(1.36829)	(3.34996)	(2.59568)

Variance Decomposition of HANGSENG:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.01711	2.94524	57.35572	17.55006	22.14898
		(1.38284)	(3.66712)	(2.44699)	(3.42635)
5.00000	0.01748	2.92662	56.63124	18.14994	22.29220
		(1.42659)	(3.50524)	(2.49228)	(3.27140)
10.00000	0.01770	2.91876	56.18333	18.73585	22.16206
		(1.42545)	(3.55234)	(2.51482)	(3.21945)

Variance Decomposition of ADR:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00669	34.74846	1.31896	46.33713	17.59544
		(2.76986)	(0.98897)	(3.27639)	(3.30750)
5.00000	0.00680	34.16020	1.81319	46.62020	17.40642
		(2.75521)	(1.18135)	(3.32047)	(3.20573)
10.00000	0.00684	33.97055	1.94697	46.79330	17.28917
		(2.74211)	(1.19897)	(3.28831)	(3.17648)

For U:LFC

Variance Decomposition of S&P500:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.01989	0.70909	0.10024	0.00112	99.18956
		(0.85276)	(0.42220)	(0.36367)	(1.03889)
5.00000	0.02045	2.57290	1.10433	0.56729	95.75548
		(1.51920)	(1.01298)	(0.80415)	(1.93157)
10.00000	0.02049	2.69242	1.29675	0.63653	95.37431
		(1.57212)	(1.04170)	(0.85244)	(2.04310)

Variance Decomposition of UNDERLYING:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00815	8.74091	0.46191	86.41959	4.37759
		(2.52390)	(0.82639)	(3.31476)	(1.72041)
5.00000	0.00824	8.74755	1.02676	84.81178	5.41392
		(2.51050)	(1.15092)	(3.15716)	(1.79863)
10.00000	0.00835	9.00922	1.50979	83.90064	5.58036
		(2.51392)	(1.43877)	(3.27478)	(1.78169)

Variance Decomposition of HANGSENG:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.01913	1.88202	52.98512	22.01528	23.11758
		(1.21278)	(3.14998)	(2.92290)	(3.42710)
5.00000	0.01950	2.53200	52.08562	22.30503	23.07735
		(1.37153)	(3.07329)	(2.89240)	(3.32116)
10.00000	0.01964	3.07280	51.04990	22.82427	23.05303
		(1.59855)	(3.16962)	(2.78993)	(3.33116)

Variance Decomposition of ADR:

Period	S.E.	ADR	HANGSENG	UNDERLYING	S&P500
2.00000	0.00664	17.87440	0.90439	68.75924	12.46197
		(1.48386)	(0.96882)	(2.85752)	(2.87012)
5.00000	0.00681	19.18140	1.78444	66.53021	12.50395
		(1.83315)	(1.26054)	(2.98029)	(2.90479)
10.00000	0.00684	19.20223	1.94318	66.30886	12.54573
		(1.88808)	(1.41072)	(3.02797)	(2.91540)

Among the four variables in the system, US market index turns out to be most exogenous since almost one hundred percent of its 2, 5, 10-day ahead forecast error variances are explained by its own innovations. Although the Hong Kong market cannot influence the US market, a substantial portion (about 23%) of the forecast error variances of the Hong Kong market index can be explained by innovations in the US market, which is not surprising due to the information leading role of the US market. The next most exogenous variable is the underlying shares returns. The majority of its forecast error variances are explained by its own innovations, but it also can be influenced by innovations in its corresponding ADRs as well as the US market. Note that for the firm U:PTR in power industry, a substantial portion (about 28%) of the forecast error variances of the underlying shares returns is explained by innovations in its corresponding ADRs, which suggests that information can also flow from ADRs back to underlying shares in power industry. In addition, as expected, the majority of forecast error variances of ADRs returns are explained by innovations originated from its underlying shares rather than itself, and innovations in US market have comparatively less explanatory power for the forecast error variances of ADRs returns.

4.5 The validity and reliability of the results

According to Holme and Solvang (1996), validity is dependent on if the model applied in the article really measures the phenomenon that it intends to measure. Since the models we use are all classical and well-known, and a deductive approach is employed in this article, so the hypotheses are established on a theoretical base implying that there exists construct validity in our research. Furthermore, many of the previous studies have used the same methodology as ours, which makes our results are comparable to theirs. However, when we construct VECM to perform Granger causality tests, we can only include lagged values on the RHS of all the equations, no contemporaneous terms, which is a limitation of EViews software. But some theories suggest Hangseng market index and the underlying shares price may have a contemporaneous influence on the ADRs price and S&P500 market index, since Hong Kong stock market is closed before NYSE opens at the same day. Further work could be done by considering contemporaneous terms in the VECM. However, this limitation is alleviated by the fact that we also present the residual correlation matrix to show the contemporaneous relationship between variables, so it cannot affect the general validity of our study.

Reliability refers to the consistency of a measure, and is determined by how the methodology has been performed and how careful the researchers have been when processing the information. In our article, we collect and process data carefully from well-known organizations such as Datastream, so the reliability of our data is considered to be sufficiently high. But note that the empirical results of variance decomposition are very sensitive to the variables ordering. (For the detailed discussion, please refer to the methodology part.) Furthermore, there is no significance discussion regarding the contemporaneous residual correlation matrix, which is due to the weakness of Eviews software. In addition, in our article we choose ADRs of five firms that each represents an industrial branch. The question remains still: does one firm also represent other firms within the same industry that have listed ADRs? Unfortunately the number of Chinese ADRs is still too limited to perform sufficiently large tests. There are only fifteen "mature" ADRs listed on NYSE for us to choose from, which greatly limits our choice and the opportunity to form portfolios. Further work could be done by also taking into consideration Chinese ADRs listed on other markets, NASDAQ for example, which may give a more comprehensive perspective regarding to price transmission dynamics of Chinese ADRs. Fortunately, however, we also perform the same research on the other ADRs listed on NYSE and their results are quite similar. Therefore, our results may still have some implications and can be validly generalized.

5. Conclusions

In this chapter we will attempt to elaborate on the results and discuss their meaning in a wider context.

In this article, we study the price transmission dynamics among Chinese ADRs, their underlying shares, US market index and Hong Kong market index. We capture how a shock in the home market is transmitted to the foreign (and vice versa), and at what speed the shock is absorbed. We also assess the relative weight of each variable in the system generating unexpected variances of its own and other variables.

We find that the ADRs price is influenced mostly by its underlying share price, which is consistent with our hypothesis. In addition, there exists a long-run equilibrium co-integration relationship among the four variables in our system. Thus, the law of one price as well as the no-arbitrage condition holds. In this respect, Chinese ADRs do not differ from ADRs of other nationalities (Kim et al (2000) and Kutan and Zhou (2006)).

Regarding diversification gains for US investors, our results indicate that Chinese ADRs are relatively independent from the behavior of the US market, suggesting that US investors can to some extent diversify their risk by investing in Chinese ADRs, which is also consistent with our hypothesis and previous studies. The exception can be found in the IT industry, where there exists a unidirectional causality relationship from S&P500 market index to the ADR price. We might have missed to capture this feature if the ADR would have been included in a portfolio. It is reasonable to believe that such high-tech firms are more sensitive to the information in the US stock market than firms in other industries.

Furthermore, at aggregate level, we have find that there is a unidirectional information flow from US market to Hong Kong market with one day lag, but not vice versa, which confirms the leading role of US market with respect to information discovery based on previous research.

With respect to informational efficiency of the markets, we find that the new information incorporated in the underlying shares price can be transmitted to the ADRs price within the same calendar day, whereas the lagged values of underlying shares price have little significantly impact on the current ADRs price. If there is a shock to one variable in the system, the shock will be transmitted and die away quickly.

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Appendix Table A: Estimation output of VECM

*The numbers in [ ] represents the corresponding t-statistics. The critical value of 5% significance level is 1.6449. (Brooks Appendix Table A2.2)

For U:CHL

Cointegrating Eq:	**CointEq1**
ADR(-1)	1
HANGSENG(-1)	-0.015655
	[-0.58629]
S&P500(-1)	-0.017353
	[-0.67010]
UNDERLYING(-1)	-0.991352
	[-133.578]
C	-1.38321

Error Correction:	**D(ADR)**	**D(HANGSENG)**	**D(S&P500)**	**D(UNDERLYING)**
CointEq1	-0.400602	0.106143	-0.006121	0.412848
	[-1.41597]	[0.98762]	[-0.06127]	[1.76911]
D(ADR(-1))	-0.184022	0.027737	-0.009873	-0.028646
	[-0.71329]	[0.28302]	[-0.10837]	[-0.13461]
D(ADR(-2))	-0.223626	-0.017847	-0.085172	-0.049868
	[-0.97118]	[-0.20403]	[-1.04746]	[-0.26255]
D(ADR(-3))	0.002137	0.045607	-0.015002	0.044351
	[0.01103]	[0.61969]	[-0.21928]	[0.27753]
D(ADR(-4))	-0.299898	-0.056493	-0.05121	-0.183558
	[-1.92972]	[-0.95692]	[-0.93313]	[-1.43191]
D(ADR(-5))	-0.235394	-0.109937	0.022877	-0.202092
	[-2.28646]	[-2.81106]	[0.62927]	[-2.37979]
D(HANGSENG(-1))	-0.513632	-0.034603	-0.09635	-0.336762
	[-1.86193]	[-0.33020]	[-0.98907]	[-1.47998]
D(HANGSENG(-2))	0.519656	0.004459	0.259828	-0.079509
	[1.88976]	[0.04268]	[2.67572]	[-0.35053]

D(HANGSENG(-3))	-0.091234	-0.026469	-0.052341	0.027262
	[-0.32501]	[-0.24822]	[-0.52802]	[0.11774]
D(HANGSENG(-4))	-0.348887	-0.181945	-0.051047	-0.26648
	[-1.25334]	[-1.72062]	[-0.51930]	[-1.16057]
D(HANGSENG(-5))	-0.231678	0.17581	-0.053251	0.151433
	[-0.87349]	[1.74493]	[-0.56855]	[0.69218]
D(S&P500(-1))	0.63511	0.431248	-0.038632	0.555896
	[3.20870]	[5.73544]	[-0.55271]	[3.40484]
D(S&P500(-2))	0.218373	0.201475	-0.024504	0.24345
	[1.03907]	[2.52365]	[-0.33018]	[1.40437]
D(S&P500(-3))	-0.252115	-0.02953	-0.073169	0.013901
	[-1.19407]	[-0.36818]	[-0.98134]	[0.07982]
D(S&P500(-4))	0.301759	0.091162	0.035038	0.246599
	[1.42313]	[1.13177]	[0.46793]	[1.40993]
D(S&P500(-5))	0.000381	0.04776	-0.044131	0.067005
	[0.00183]	[0.60467]	[-0.60104]	[0.39068]
D(UNDERLYING(-1))	0.297201	-0.044138	0.051552	0.103753
	[1.08110]	[-0.42265]	[0.53104]	[0.45755]
D(UNDERLYING(-2))	-9.78E-05	0.002017	-0.021303	0.05852
	[-0.00039]	[0.02101]	[-0.23871]	[0.28073]
D(UNDERLYING(-3))	0.017508	-0.026344	0.012787	-0.065979
	[0.08009]	[-0.31722]	[0.16564]	[-0.36588]
D(UNDERLYING(-4))	0.434576	0.154695	0.053803	0.297678
	[2.28968]	[2.14559]	[0.80275]	[1.90142]
D(UNDERLYING(-5))	0.245395	0.009219	-0.031631	0.08079
	[1.54135]	[0.15244]	[-0.56263]	[0.61520]
C	0.002243	0.000522	0.000531	0.002055
	[2.33686]	[1.43240]	[1.56667]	[2.59584]

For U:CEA

Cointegrating Eq:	CointEq1
ADR(-1)	1
HANGSENG(-1)	0.118251
	[2.00048]
PRICES&P500(-1)	-0.218228
	[-2.03588]
UNDERLYING(-1)	-1.002715
	[-55.0042]
C	-3.951633

Error Correction:	D(ADR)	D(HANGSENG)	D(S&P500)	D(UNDERLYING)
CointEq1	-0.325187	-0.0199	-0.014028	0.030292
	[-3.72417]	[-0.54155]	[-0.41076]	[0.30328]
D(ADR(-1))	0.052998	0.089608	-0.012929	0.342481
	[0.54663]	[2.19619]	[-0.34096]	[3.08819]
D(ADR(-2))	-0.082616	-0.008959	-0.025117	0.018891
	[-0.86922]	[-0.22399]	[-0.67566]	[0.17376]
D(ADR(-3))	0.03386	-0.004867	-0.014496	0.078062
	[0.37309]	[-0.12742]	[-0.40838]	[0.75196]
D(ADR(-4))	-0.157126	-0.009118	-0.01726	-0.07519
	[-1.87137]	[-0.25805]	[-0.52560]	[-0.78288]
D(ADR(-5))	-0.133878	-0.051802	-0.046035	-0.107072
	[-1.83074]	[-1.68324]	[-1.60954]	[-1.28002]
D(HANGSENG(-1))	0.025483	-0.091098	-0.041904	0.067246
	[0.21534]	[-1.82926]	[-0.90540]	[0.49679]
D(HANGSENG(-2))	0.082959	-0.038686	0.063801	-0.033461
	[0.70411]	[-0.78021]	[1.38453]	[-0.24828]
D(HANGSENG(-3))	0.172438	0.015957	-0.071212	0.200121
	[1.46347]	[0.32179]	[-1.54526]	[1.48481]

D(HANGSENG(-4))	0.048311	0.037827	-0.043061	0.080166
	[0.41312]	[0.76862]	[-0.94147]	[0.59930]
D(HANGSENG(-5))	0.05049	0.045562	-0.070138	-0.081656
	[0.48548]	[1.04101]	[-1.72434]	[-0.68642]
D(S&P500(-1))	0.112835	0.535137	-0.065373	0.164053
	[0.85198]	[9.60132]	[-1.26206]	[1.08292]
D(S&P500(-2))	-0.007468	0.203845	-0.074135	0.096858
	[-0.05072]	[3.28994]	[-1.28744]	[0.57513]
D(S&P500(-3))	-0.062379	0.085084	-0.010548	0.120453
	[-0.42024]	[1.36201]	[-0.18169]	[0.70941]
D(S&P500(-4))	0.107305	-0.033554	0.016785	0.071239
	[0.72432]	[-0.53819]	[0.28969]	[0.42040]
D(S&P500(-5))	-0.009783	-0.023027	0.058546	0.14303
	[-0.06746]	[-0.37730]	[1.03221]	[0.86225]
D(UNDERLYING(-1))	0.02412	-0.050948	0.009701	-0.224141
	[0.25072]	[-1.25840]	[0.25782]	[-2.03688]
D(UNDERLYING(-2))	0.013423	-0.01659	0.025184	-0.115188
	[0.14481]	[-0.42529]	[0.69466]	[-1.08640]
D(UNDERLYING(-3))	-0.071132	0.006422	0.035479	-0.153348
	[-0.81451]	[0.17474]	[1.03873]	[-1.53511]
D(UNDERLYING(-4))	0.024974	-0.04296	0.028616	-0.044939
	[0.30737]	[-1.25638]	[0.90048]	[-0.48353]
D(UNDERLYING(-5))	0.101588	0.027891	0.006994	0.081201
	[1.44457]	[0.94242]	[0.25428]	[1.00945]
C	-0.000803	0.000435	0.000458	-0.000826
	[-0.96080]	[1.23638]	[1.40163]	[-0.86415]

For U:CBA

Cointegrating Eq:	CointEq1
ADR(-1)	1
HANGSENG(-1)	0.021812
	[0.52204]
S&P500(-1)	-0.117562
	[-1.43430]
UNDERLYING(-1)	-1.002958
	[-77.5474]
C	-3.934639

Error Correction:	D(ADR)	D(HANGSENG)	D(S&P500)	D(UNDERLYING)
CointEq1	-0.146171	0.066384	-0.009315	0.319496
	[-0.89694]	[1.45825]	[-0.22795]	[2.14168]
D(ADR(-1))	-0.052337	-0.028779	0.056572	0.255255
	[-0.31769]	[-0.62535]	[1.36942]	[1.69258]
D(ADR(-2))	-0.129719	-0.05554	0.043354	0.034438
	[-0.82724]	[-1.26793]	[1.10255]	[0.23991]
D(ADR(-3))	0.042532	-0.020171	0.113535	0.108131
	[0.29187]	[-0.49553]	[3.10704]	[0.81060]
D(ADR(-4))	-0.033338	-0.047761	0.078594	0.007772
	[-0.25434]	[-1.30444]	[2.39123]	[0.06478]
D(ADR(-5))	-0.118602	-0.019246	0.06869	-0.136132
	[-1.12370]	[-0.65276]	[2.59537]	[-1.40897]
D(HANGSENG(-1))	-0.149678	-0.086944	-0.036758	-0.021884
	[-0.81629]	[-1.69742]	[-0.79944]	[-0.13037]
D(HANGSENG(-2))	0.08082	-0.049081	0.069669	-0.089111
	[0.44126]	[-0.95930]	[1.51691]	[-0.53149]
D(HANGSENG(-3))	0.055744	0.001568	-0.059687	-0.032417
	[0.30270]	[0.03048]	[-1.29254]	[-0.19230]

D(HANGSENG(-4))	0.173594	0.003382	-0.065169	0.277259
	[0.95532]	[0.06662]	[-1.43022]	[1.66680]
D(HANGSENG(-5))	0.155931	0.042317	-0.075045	0.17526
	[0.94207]	[0.91523]	[-1.80809]	[1.15670]
D(S&P500(-1))	0.471944	0.563196	-0.124241	0.355057
	[2.23213]	[9.53573]	[-2.34337]	[1.83449]
D(S&P500(-2))	0.241573	0.191703	-0.137099	0.214808
	[1.02682]	[2.91702]	[-2.32396]	[0.99743]
D(S&P500(-3))	-0.096065	0.051949	-0.083528	-0.102919
	[-0.40732]	[0.78852]	[-1.41236]	[-0.47670]
D(S&P500(-4))	-0.268247	-0.041814	-0.020133	-0.131603
	[-1.13728]	[-0.63463]	[-0.34041]	[-0.60952]
D(S&P500(-5))	0.029812	-0.057767	0.023488	0.129724
	[0.13058]	[-0.90583]	[0.41030]	[0.62074]
D(UNDERLYING(-1))	0.13765	0.020408	-0.038221	-0.143207
	[0.82248]	[0.43652]	[-0.91075]	[-0.93476]
D(UNDERLYING(-2))	0.039286	0.067427	-0.044209	-0.118392
	[0.24990]	[1.53539]	[-1.12146]	[-0.82268]
D(UNDERLYING(-3))	0.051712	0.036148	-0.089744	-0.016962
	[0.35317]	[0.88377]	[-2.44427]	[-0.12655]
D(UNDERLYING(-4))	0.030532	0.04686	-0.051354	-0.047167
	[0.23396]	[1.28543]	[-1.56929]	[-0.39483]
D(UNDERLYING(-5))	0.074738	0.010754	-0.056262	0.082859
	[0.72732]	[0.37463]	[-2.18343]	[0.88086]
C	-0.000708	0.000524	0.00058	-0.000757
	[-0.55348]	[1.46644]	[1.80868]	[-0.64700]

For U:PTR

Cointegrating Eq:	CointEq1
ADR(-1)	1
HANGSENG(-1)	-0.041104
	[-1.60540]
S&P500(-1)	0.01091
	[0.31178]
UNDERLYING(-1)	-0.982515
	[-144.437]
C	-4.368918

Error Correction:	D(ADR)	D(HANGSENG)	D(S&P500)	D(UNDERLYING)
CointEq1	0.326178	0.354533	0.021138	0.921964
	[1.62262]	[4.44176]	[0.27716]	[6.15885]
D(ADR(-1))	-0.20314	-0.180153	0.015054	0.039768
	[-1.03896]	[-2.32049]	[0.20293]	[0.27312]
D(ADR(-2))	-0.156918	-0.164726	-0.010825	0.073158
	[-0.87975]	[-2.32588]	[-0.15997]	[0.55077]
D(ADR(-3))	-0.260542	-0.131335	-0.020965	-0.068365
	[-1.65745]	[-2.10418]	[-0.35152]	[-0.58401]
D(ADR(-4))	-0.193303	-0.12972	-0.024442	-0.01535
	[-1.45905]	[-2.46590]	[-0.48627]	[-0.15558]
D(ADR(-5))	-0.133605	-0.089814	0.029153	-0.067507
	[-1.43452]	[-2.42865]	[0.82503]	[-0.97332]
D(HANGSENG(-1))	-0.331744	-0.122957	0.001066	-0.179263
	[-2.38242]	[-2.22384]	[0.02018]	[-1.72874]
D(HANGSENG(-2))	-0.023374	-0.050173	0.062653	-0.065438
	[-0.16719]	[-0.90385]	[1.18121]	[-0.62854]
D(HANGSENG(-3))	-0.147893	-0.004027	-0.06804	-0.026003
	[-1.05479]	[-0.07233]	[-1.27905]	[-0.24904]

D(HANGSENG(-4))	0.162056	-0.004122	-0.025821	0.046394
	[1.17208]	[-0.07508]	[-0.49223]	[0.45059]
D(HANGSENG(-5))	-0.113773	0.045258	-0.112713	0.139838
	[-0.88819]	[0.88982]	[-2.31923]	[1.46595]
D(S&P500(-1))	-0.078901	0.398226	-0.100915	-0.16699
	[-0.51306]	[6.52160]	[-1.72960]	[-1.45815]
D(S&P500(-2))	0.125154	0.136482	-0.077399	0.051895
	[0.74894]	[2.05689]	[-1.22078]	[0.41701]
D(S&P500(-3))	0.16076	0.0228	-0.006954	0.125895
	[0.95460]	[0.34097]	[-0.10883]	[1.00387]
D(S&P500(-4))	-0.076901	-0.06787	0.029001	-0.034126
	[-0.45780]	[-1.01756]	[0.45504]	[-0.27280]
D(S&P500(-5))	-0.078786	-0.065085	0.007989	-0.068088
	[-0.47593]	[-0.99019]	[0.12720]	[-0.55232]
D(UNDERLYING(-1))	0.124401	0.178291	-0.040346	0.001419
	[0.66267]	[2.39187]	[-0.56647]	[0.01015]
D(UNDERLYING(-2))	0.30368	0.194467	0.031648	0.01675
	[1.81314]	[2.92414]	[0.49804]	[0.13429]
D(UNDERLYING(-3))	0.243228	0.143712	0.01794	0.020216
	[1.65880]	[2.46837]	[0.32248]	[0.18514]
D(UNDERLYING(-4))	0.118965	0.122882	-0.009941	0.037623
	[1.02392]	[2.66362]	[-0.22551]	[0.43483]
D(UNDERLYING(-5))	0.060936	0.016126	0.013492	-0.026491
	[0.76888]	[0.51244]	[0.44872]	[-0.44886]
C	0.002172	0.000721	0.000467	0.001824
	[2.45127]	[2.04977]	[1.38910]	[2.76408]

For U:LFC

Cointegrating Eq:	CointEq1
ADR(-1)	1
HANGSENG(-1)	-0.059246
	[-2.21342]
S&P500(-1)	0.004407
	[0.12265]
UNDERLYING(-1)	-0.992819
	[-228.650]
C	-3.270609

Error Correction:	D(ADR)	D(HANGSENG)	D(S&P500)	D(UNDERLYING)
CointEq1	0.308746	0.296272	0.080461	0.839713
	[1.32326]	[3.60254]	[1.02928]	[4.05965]
D(ADR(-1))	-0.299004	-0.116267	-0.001154	-0.033294
	[-1.32034]	[-1.45660]	[-0.01520]	[-0.16584]
D(ADR(-2))	-0.439217	-0.139494	-0.063109	-0.134102
	[-2.12377]	[-1.91364]	[-0.91080]	[-0.73144]
D(ADR(-3))	-0.137085	-0.004868	0.047876	-0.000775
	[-0.75117]	[-0.07568]	[0.78300]	[-0.00479]
D(ADR(-4))	-0.227019	-0.103662	-0.014034	-0.097801
	[-1.50200]	[-1.94582]	[-0.27714]	[-0.72990]
D(ADR(-5))	-0.127417	-0.079283	0.027721	-0.084668
	[-1.18404]	[-2.09024]	[0.76887]	[-0.88751]
D(HANGSENG(-1))	-0.304602	-0.008922	-0.02845	-0.147499
	[-1.89169]	[-0.15720]	[-0.52736]	[-1.03329]
D(HANGSENG(-2))	0.188179	0.034496	0.107795	0.090128
	[1.16306]	[0.60489]	[1.98853]	[0.62835]
D(HANGSENG(-3))	-0.065168	0.013801	-0.045287	-0.019365
	[-0.40342]	[0.24238]	[-0.83676]	[-0.13522]

D(HANGSENG(-4))	0.252441	0.011424	-0.020194	0.242499
	[1.57172]	[0.20179]	[-0.37527]	[1.70311]
D(HANGSENG(-5))	0.013936	0.052168	-0.071664	0.116718
	[0.09430]	[1.00149]	[-1.44732]	[0.89088]
D(S&P500(-1))	-0.250882	0.401538	-0.134018	-0.179493
	[-1.34014]	[6.08532]	[-2.13672]	[-1.08154]
D(S&P500(-2))	0.382606	0.136897	-0.071956	0.398583
	[1.89909]	[1.92781]	[-1.06602]	[2.23166]
D(S&P500(-3))	-0.050213	-0.058747	-0.103843	0.056392
	[-0.24895]	[-0.82633]	[-1.53664]	[0.31537]
D(S&P500(-4))	0.152141	0.044644	0.053274	0.138928
	[0.75711]	[0.63030]	[0.79128]	[0.77986]
D(S&P500(-5))	-0.022652	-0.040331	0.006162	-0.081664
	[-0.11399]	[-0.57580]	[0.09255]	[-0.46356]
D(UNDERLYING(-1))	0.328548	0.066483	0.010741	0.064614
	[1.46603]	[0.84166]	[0.14306]	[0.32523]
D(UNDERLYING(-2))	0.298852	0.089481	0.021887	-0.00888
	[1.46418]	[1.24379]	[0.32006]	[-0.04907]
D(UNDERLYING(-3))	0.051547	0.001829	-0.054332	-0.060997
	[0.28449]	[0.02864]	[-0.89500]	[-0.37974]
D(UNDERLYING(-4))	0.064811	0.083233	-0.002268	-0.026568
	[0.43866]	[1.59828]	[-0.04581]	[-0.20284]
D(UNDERLYING(-5))	0.077702	0.018557	-0.03279	0.078511
	[0.70009]	[0.47435]	[-0.88178]	[0.79794]
C	0.003678	0.00097	0.000611	0.003188
	[3.60666]	[2.69965]	[1.78765]	[3.52607]

APPENDIX TABLE B: Chinese ADRs listed on NYSE

Company Name	Ticker *)	CUSIP **)	UDL SEDOL ***)	Ratio	Exchange	Country	Sector	Depositary	Base date
CHINA SOUTHERN AIRLINES CO LTD	U:ZNH	169409 10 9	60136 93 K:CSA	1 : 50	NYSE	CHINA	AIRLINES	BNY	Jul 31,1997
CHINA MOBILE LTD	U:CHL	16941M 10 9	60735 56 K:CHT	1 : 5	NYSE	CHINA	TELECOMMUNICATIONS	BNY	Oct 22,1997
HUANENG POWER INTERNATIONAL INC	U:HNP	443304 10 0	60996 71 K:HPI	1 : 40	NYSE	CHINA	ELECTRIC	BNY	Oct 6,1994
YANZHOU COAL MINING CO LTD	U:YZC	984846 10 5	61098 93 K:YNCL	1 : 50	NYSE	CHINA	COAL	BNY	Apr 1,1998
CHINA EASTERN AIRLINES CORP LTD	U:CEA	16937R 10 4	61713 75 K:CHEA	1 : 100	NYSE	CHINA	AIRLINES	BNY	Feb 4,1997
BRILLIANCE CHINA AUTOMOTIVE HOLDINGS LTD	U:CBA	10949Q 10 5	61814 82 K:CBA	1 : 100	NYSE	CHINA	AUTO MANUFACTURERS	BNY	Oct 9,1992
PETROCHINA CO LTD	U:PTR	71646E 10 0	62265 76 K:PECH	1 : 100	NYSE	CHINA	OIL&GAS	BNY	Apr 6,2000
CHINA UNICOM LTD	U:CHU	16945R 10 4	62638 30 K:UNIC	1 : 10	NYSE	CHINA	TELECOMMUNICATIONS	BNY	Jun 21,2000
CHINA PETROLEUM & CHEMICAL CORP	U:SNP	16941R 10 8	62918 19 K:CHPE	1 : 100	NYSE	CHINA	OIL&GAS	CIT	Oct 18,2000
GUANGSHEN RAILWAY CO LTD	U:GSH	40065W 10 7	63887 00 K:GHEN	1 : 50	NYSE	CHINA	TRANSPORTATION	JPM	May 13,1996
ALUMINUM CORP OF CHINA LTD	U:ACH	022276 10 9	64253 95 K:ALUM	1 : 100	NYSE	CHINA	MINING	BNY	Dec 11,2001
CHINA TELECOM CORP LTD	U:CHA	169426 10 3	65593 35 K:CTC	1 : 100	NYSE	CHINA	TELECOMMUNICATIONS	BNY	Nov 14,2002
CHINA LIFE INSURANCE	U:LFC	16939P 10 6	67189 76 K:CLS	1 : 40	NYSE	CHINA	INSURANCE	JPM	Dec 17,2003
SEMICONDUCTOR MANUFACTURING INTERNATIONAL CORP	U:SMI	81663N 20 6	67434 73 K:SMIC	1 : 50	NYSE	CHINA	SEMICONDUCTORS	JPM	Mar 17,2004
SINOPEC SHANGHAI PETROCHEMICAL CO LTD	U:SHI	82935M 10 9	67974 58 K:SHPT	1 : 100	NYSE	CHINA	CHEMICALS	BNY	Jul 26,1993
NEW ORIENTAL EDUCATION & TECHNOLOGY GROUP	EDU	647581 10 7	B1DDS 19	1 : 4	NYSE	CHINA	COMMERCIAL SERVICES	DB	
MINDRAY MEDICAL INTERNATIONAL LTD	MR	602675 10 0		1 : 1	NYSE	CHINA	HEALTHCARE-PRODUCTS	BNY	
SUNTECH POWER HOLDINGS CO LTD	STP	86800C 10 4		1 : 1	NYSE	CHINA	ENERGY-ALTERNATE SOURCES	BNY	

*) The letters that identify a company's securities on the different exchanges.

**) Unique identification number assigned to a stock or bond issuance to facilitate clearing operations. The numbering system used in the U.S. is administered by the Committee on Uniform Security Identification Procedures (CUSIP).

***) Stock Exchange Daily Official List. The official seven-digit identification number of the London Stock Exchange.